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Organic Emissions From Automobile Interiors

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ORGANIC EMISSIONS FROM AUTOMOBILE INTERIORS

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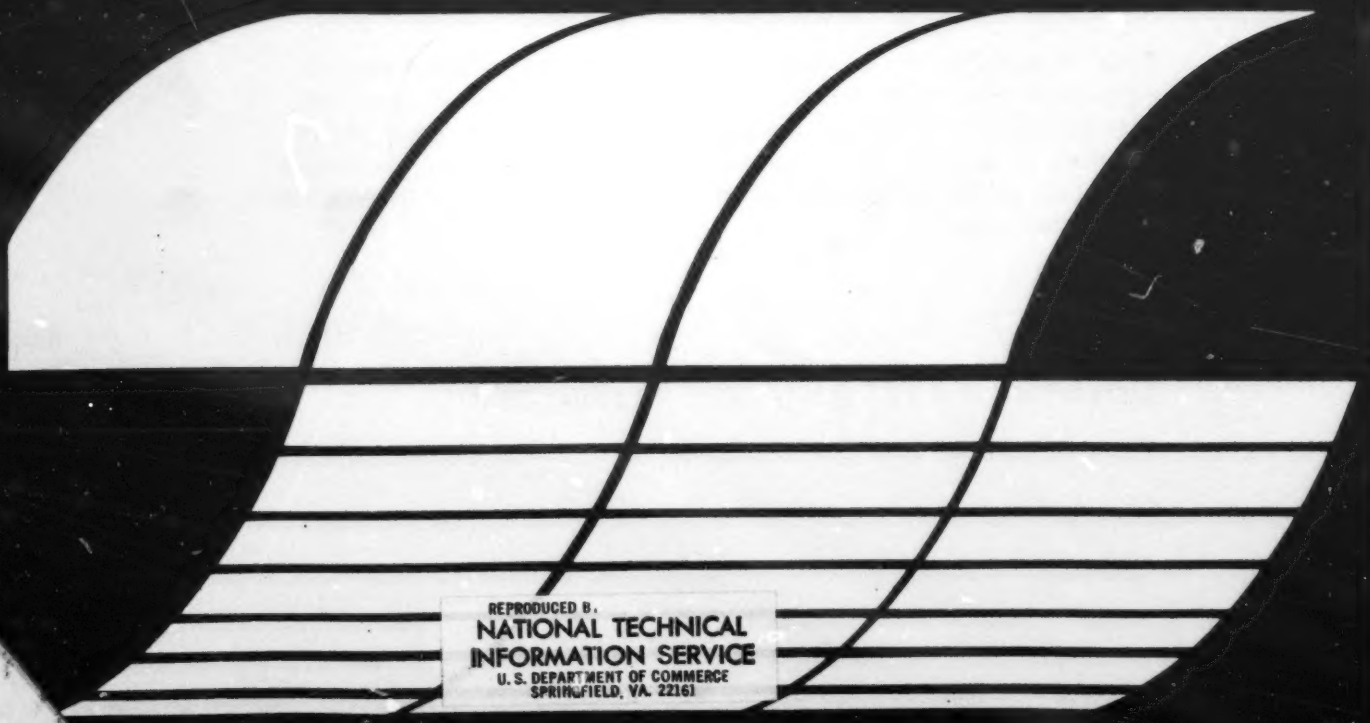

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16. ABSTRACT The report gives results of an evaluation of six subcompact automobiles for the emission of vinyl chloride monomer (VCM) and other organics into the passenger compartment. Evaluated were a Ford Pinto, AMC Gremlin, GMC Vega, GMC Chevette, NMC Datsun 710, and VW Rabbit. VCM was quantified using charcoal cartridges interfaced with gas/liquid chromatography-mass spectrometry in the single-ion detection mode. VCM levels in the Pinto, Gremlin, Vega, and Chevette were less than the 50 ppb detection limit. With improved instrumental parameters, a 2 ppb detection limit was obtained. Under these conditions, VCM was not detected in the Chevette, but was detected in the Rabbit and the Datsun 710. Samples were taken for qualitative gas/liquid chromatography-mass spectrometric analysis of each automobile, using Tenax G.C. sorbent. This analysis produced a composite list of 147 organic compounds which were identified in the automobiles and not in the ambient air in the vicinity of the test. Another 36 compounds were tentatively identified.

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ORGANIC EMISSIONS FROM AUTOMOBILE INTERIORS

by

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ABSTRACT

This research program was initiated to evaluate the potential for exposure of the general population to organic emissions of automobile interiors and specifically to vinyl chloride monomer (VCM). This program was intended as a pilot study to evaluate (a) whether there exists a possible hazard due to VCM or other hazardous organics and (b) the test conditions and relevent parameters for further testing of a statistically significant sample of automobiles should that be undertaken subsequent to this study.

Six subcompact automobiles (Ford Pinto, AMC Gremlin, GMC Vega, GMC Chevette, NMC Datsun 710 and VW Rabbit) were evaluated in this study for the emission of VCM and other organics into the passenger compartment. The quantitation of VCM was achieved using Lot No. 104 SKC charcoal cartridges interfaced with gas-liquid chromatography-mass spectrometry (GLC/MS) in the single ion mode. The interiors of the automobiles were thermostatically controlled at either 45 or 65°C for 3 hrs before sampling the car interior. Each automobile was sampled for VCM at both temperatures. Levels of VCM in the Ford Pinto, AMC Gremlin, GMC Vega and GMC Chevette were less than the detection limit of 50 ppb. With improved instrumental parameters a limit of detection of 2 ppb was attained. Under these conditions no VCM was detected in the GMC Chevette. VCM was detected in the VW Rabbit at 4±3 ppb when sampled at 65°C and less than 2 ppb at 45°C. The NMC Datsun 710 was found to produce VCM levels of 7±2 ppb and 3±1 ppb at 65° and 45°C, respectively.

In accordance with E.P.A. proposed rules as set forth in the Federal Register, Vol. 42, p. 28154, 1977, these low levels must be regarded as unacceptable.

Samples for qualitative GLC/MS analysis of each automobile for other organics were taken at 65°C using Tenax GC sorbent. This analysis produced a composite list of 147 organic compounds which were identified in the automobiles but not in the ambient air in the vicinity of the test. Another 36 compounds were tentatively identified. Inclusion in the latter group resulted when the compound was either in very small amounts or there were possible interferences.

Of the compounds identified in automobile interiors, aniline, biphenyl, 1,2-dibromoethane (tentative identification), dichlorobenzene (tentative identification), dimethylphenol isomers (some isomers are carcinogenic), isobutyl alcohol, maleic anhydride (tentative identification), naphthalene and 1,1,1-trichloroethane are listed as having carcinogenic or neoplastic effects according to the Registry of Toxic Effects of Chemical Substances, 1976 Edition. Benzene, carbon tetrachloride, chloroform and phenol are also listed as carcinogenic or neoplastic; however, they were found in the background as well as in the automobile interiors.

Further investigation of these emissions seems warranted based upon these preliminary results; however, it will have to be initiated by that segment of the E.P.A. specifically responsible for automobile emissions.

This report was submitted in fulfillment of Contract No. 68-02-1325 by Research Triangle Institute under sponsorship of the U. S. Environmental Protection Agency. This report covers the period May 15, 1976 to December 22, 1976, and work was completed as of April 1, 1977.

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SECTION 1
INTRODUCTION

The possibility of toxic or carcinogenic organic compounds being volatilized into the interior of automobiles as a result of the extensive use of plastics has aroused concern. A number of toxic compounds have been postulated as arising from the pyrolysis of various plastics at 65°C, and these have been examined.[1-5] However, even qualitative information on the identity of these compounds actually occurring in the automobile interiors is incomplete. Vinyl chloride monomer (VCM) would be expected to be a likely offender due to the abundance of polyvinyl chloride (PVC) in automobile interiors. Since VCM is a suspected carcinogen in man[6,7] a very careful assessment of its presence and amount in automobile interiors should be made using "worst case" conditions.

The "worst case" would provide an upper limit on the exposure to the public, and an appropriately designed experiment should permit estimation of levels under less extreme conditions. The inclusion of qualitative information on other compounds in this study avoids omission of other hazardous compounds.

Parameters which are likely to be relevant to the selection of "worst case" conditions are newness of the automobile, plastic-content-to-volume ratio, and temperature. The age of a test automobile is expected to affect the amount of residual VCM in the PVC components. Temperature and ventilation history may have a very substantial influence on the residual VCM; however, these parameters were not controllable for the period between the automobile's manufacture and initiation of the study. If extremes of temperature history are available that information would certainly be useful, but not essential. Subcompact cars potentially represent the "worst case" for plastic-content-to-volume-of-interior

ratio and consequently should accumulate the highest concentrations over a given interval. The last parameter for the "worst case" criteria is temperature. The volatilization of VCM would be expected to be diffusion controlled since it is a gas at normal ambient temperatures (boiling point: -13°C). The temperature dependence of the diffusion rate will depend upon the properties of the particular polymer. Numerous different formulations and applications of PVC from foams to solid sheets are found in automobile interiors; therefore, only actual measurement of the resulting VCM levels as a function of temperature and time will yield meaningful information.

The experimental design used in this study was selected to maximize the information content for a manageable number of samples. The identification of other organics emitted into the automobile passenger compartment was designed to probe the potential exposure to hazardous organic compounds. In this case, only qualitative information at the highest selected temperature was sought.

SECTION 2
CONCLUSIONS

Six subcompact automobiles (Ford Pinto, AMC Gremlin, GMC Vega, GMC Chevette, NMC Datsun 710 and VW Rabbit) were evaluated in this study for the emission of vinyl chloride monomer (VCM) and other organics into the passenger compartment. The quantitation of VCM was obtained using Lot 104 SKC charcoal cartridges interfaced with gas-liquid chromatography-mass spectometry (GLC/MS) in the single ion mode. The interiors of the automobiles were thermostatically controlled at either 45 or 65°C for 3 hrs before sampling the car interior. Each automobile was sampled for VCM at both temperatures. Levels of VCM in the Ford Pinto, AMC Gremlin, GMC Vega and GMC Chevette were less than the detection limit of 50 ppb. With improved instrumental parameters a limit of detection of 2 ppb was obtained. Under these conditions no VCM was detected in the GMC Chevette. Vinyl chloride monomer was detected in the VW Rabbit at 4±3 ppb (± 3 refers to standard deviation of duplicate samples) when sampled at 65°C and less than 2 ppb at 45°C. The NMC Datsun 710 was found to produce VCM levels of 7±2 ppb and 3±1 ppb at 65° and 45°C, respectively. Since the analysis of VCM in the interiors of Ford Pinto, AMC Gremlin and GMC Vega was not repeated with the lower limit of detection, no comparison of their VCM levels with the other three automobiles can be made. In accordance with EPA proposed rules as set forth in the Federal Register,[8] these low levels must be regarded as unacceptable.

An array of times as well as temperatures was originally proposed to indicate aging effects and one automobile in the study, the Chevette, was sampled at 1 month and 3 months of age. The VCM levels were below the limit of detection at both sampling times. Although the limit of

detection changed between the two times, no inference may be drawn from the results except that the levels were below the limits of detection of 50 and 2 ppb at 1 and 3 months respectively. It should be pointed out that 50 ppb is regarded as the usual limit of detection of VCM analyses and that the levels found in the Rabbit and Datsun 710 would not normally have been detected.

The selection of new compact automobiles sampled at elevated temperatures was based on the assumption that this would represent the "worst case" for accumulation of VCM in the passenger compartment. The results of this study probably represent an upper range for VCM exposure due to the use of polyvinyl chloride in automobile manufacture.

Samples for qualitative GLC/MS analysis of each automobile for other organics were taken at 65°C using Tenax GC sorbent. This analysis produced a composited list of 147 organic compounds which were identified in the automobiles but not in the ambient air in the vicinity of the test. Another 36 compounds were tentatively identified. Inclusion in the latter group resulted when the compound was either in very small amounts or there were possible interferences. Of the compounds identified in automobile interiors, aniline, biphenyl, 1,2-dibromoethane (tentative identification), dichlorobenzene (tentative identification), dimethylphenol isomers (some isomers are carcinogenic), isobutyl alcohol, maleic anhydride (tentative identification), naphthalene and 1,1,1-trichloroethane are listed as having carcinogenic or neoplastic activity; however, they were found in the background as well as in the automobile interiors.

SECTION 3
RECOMMENDATIONS

Since the Environmental Protection Agency has set the goal of zero emission for vinyl chloride monomer[8] the low levels found in this study must be regarded as unacceptable. Further study of a larger, more statistically significant sample is recommended before any action is taken.

Several other compounds were found in the course of this study which are listed as having carcinogenic or neoplastic effects.[9] Further quantitative evaluation of these compounds should be included in any vinyl chloride evaluation which might be undertaken.

SECTION 4

EXPERIMENTAL PROCEDURES

SAMPLE DESIGN

Selection of Test Automobiles

Subcompact model cars, potentially represent the worst case of all models where the extent of plastic utilization to interior volumes is concerned. For this reason the subcompact was used for all tests.

The selection of the manufacturers of the test automobiles is a more complex problem. The number of cars to be evaluated was limited to six; however, the number of manufacturers of subcompact cars substantially exceeds this number. Initially a random selection was proposed with the probability of selecting each manufacturer weighed according to their percentage of the total subcompact sales. This selection would represent a random sample of the subcompact car industry as a whole; however, the practical matter of obtaining automobiles suitable for this study narrowed the range of selection to those automobiles which represent the greatest portion of subcompact sales (i.e., Ford Pinto, AMC Gremlin, GMC Vega, GMC Chevette, NMC Datsun 710 and VW Rabbit).

Parameter Evaluation

The evaluation of the VCM hazard requires knowledge of its concentration in the interior of a representative sample of automobiles. There are several parameters which would obviously affect the buildup of VCM. The most prominent among these are the temperature of the automobile interior and its age. The sampling matrix originally proposed for this study evaluated these parameters.

The plan called for automobiles to be selected whose ages were known to be between 30 and 90 days. This selection would have insured that in a 60-day experiment the age dependence data for all of the cars would overlap. If for some reason the necessary make, model and age requirements were not met, the age requirement would be altered in one of

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the two following ways without substantial loss of information:

(1) sample over a 90-day period
selecting cars 30 to 120 days old, or

(2) sample over a 60-day period
selecting cars 60 to 120 days old.

Assuming the sample contaied cars 30 to 90 days old, the sampling would be performed at 30-day intervals to obtain three time points for each automobile. Although the age criterion was broader than planned for cars in the study (30-120 days), the sample still represented a group of fairly new automobiles.

The second controlled parameter, temperature, was to have been evaluated at three levels, 25°C, 45°C and 68°C. These were selected as representative of normal ambient (77°F), high ambient (113°F) and an extremely high, but possible temperature (154°F).

A matrix of the temperature and age levels was selected which would evaluate both parameters while minimizing the number of analyses. The matrix of measurements which was originally planned is shown in Table 1.

Table 1

MEASUREMENT MATRIX

Days / T°C	t^a	t + 30 days	t + 60 days
25		X	X
45	X		X
68	X	X	

[a] t = age of car at beginning of study.

Using this array, six automobiles may be evaluated for two parameters at three levels each with only 36 analyses. Of course, because all three levels of temperature and age are not evaluated for each car, this implies that some information is lost on the interactions between these parameters.

In the actual experiment the sampling array was truncated after the first period due to the very low to nondetectable amounts of VCM found. The maximum temperature which could be satisfactorily maintained was 65°C; therefore, this temperature was substituted for 68°C in Table 1. The detailed test procedure is in Appendix A.

SAMPLING FOR QUALITATIVE ANALYSIS

A detailed description of the sampling procedure is included in Appendix A.

Samples from each automobile were collected at an interior temperature of 65°C using Tenax GC cartridges (2.2 g sorbent each). Blanks of the purge gas were to be taken to pinpoint the car interior as the source and to access the background due to transportation and handling. Since the purge proved to be an impractical and uncertain method of lowering and/or establishing the background, the ambient air adjacent to the study site (outside of the Gremlin in a calm area) was sampled. The analysis was qualitative in nature; hence, background compounds were recognized on a present or absent basis. This qualitative basis does not permit the recognition of enrichment of compounds in the auto interior. The ambient air sample was typical for a nonindustrial urban area and was used as baseline for the entire study.

QUALITY CONTROL

The value of any analytical procedure is substantially influenced by the control data accumulated in the sampling and analysis process. This factor becomes more important as lower concentrations or more ubiquitous compounds are sought. Blanks (unsampled cartridges in the case of charcoal, ambient air in the case of Tenax) were prepared for each group of samples collected and subjected to the same rigors of transportation and storage as the samples.

In order to control both the effects of recent ventilation and ambient levels of organic pollutants, it was proposed that the automobiles be purged with clean air (charcoal filtered) before each experiment. This purge would facilitate the evaluation of the GLC/MS analysis of the organic vapors arising from the plastic materials by removing the normal ambient air hydrocarbons. The purge proved to be impractical in several respects. First, because the volume which needed to be exchanged was large, a long cycle time would be required to dilute the interior compartment with "clean" air. Second, infiltration of air into the passenger compartment was significant and continued throughout the test. The cars were to be sealed after the purge for a set equilibration period determined in a one-car pilot experiment, perhaps 8-18 hours. In actual tests, the 65°C temperature could be maintained for only 4 to 5 hours during the hottest portion of the day; therefore, this period was used whether equilibrium was obtained or not. This approach provided no control over artifacts from ambient air, except that provided by control blanks. More significantly, no control could be obtained with an assembled automobile which would correct for the contamination of the interior by fuel vapors and auto exhaust.

ANALYTICAL METHODS

Vinyl Chloride Monomer

The quantitative analysis of VCM was accomplished using cartridge desorption interfaced to a capillary gas chromatograph/mass spectrometer. This system had been used with success previously in the single ion monitor mode for the quantitation of N-nitrosodimethylamine in complex mixtures. The same technique is applicable to the analysis of VCM. Two important factors are very favorable for the VCM analysis: chromatographic separation and a unique ion (Figure 1). Limits of detection with this method were controlled primarily by the sample volume collected on the cartridge. Originally Tenax GC was proposed as the collection medium. However, for good quantitation, the sample volume with the standard 2.2 g Tenax GC cartridge should not exceed 0.5 ℓ. This does not leave a large margin for such factors as the effects of temperature on breakthrough volume. In view of this, another sorbent, activated charcoal (Lot 104 Charcoal S.K.C., Philadelphia,

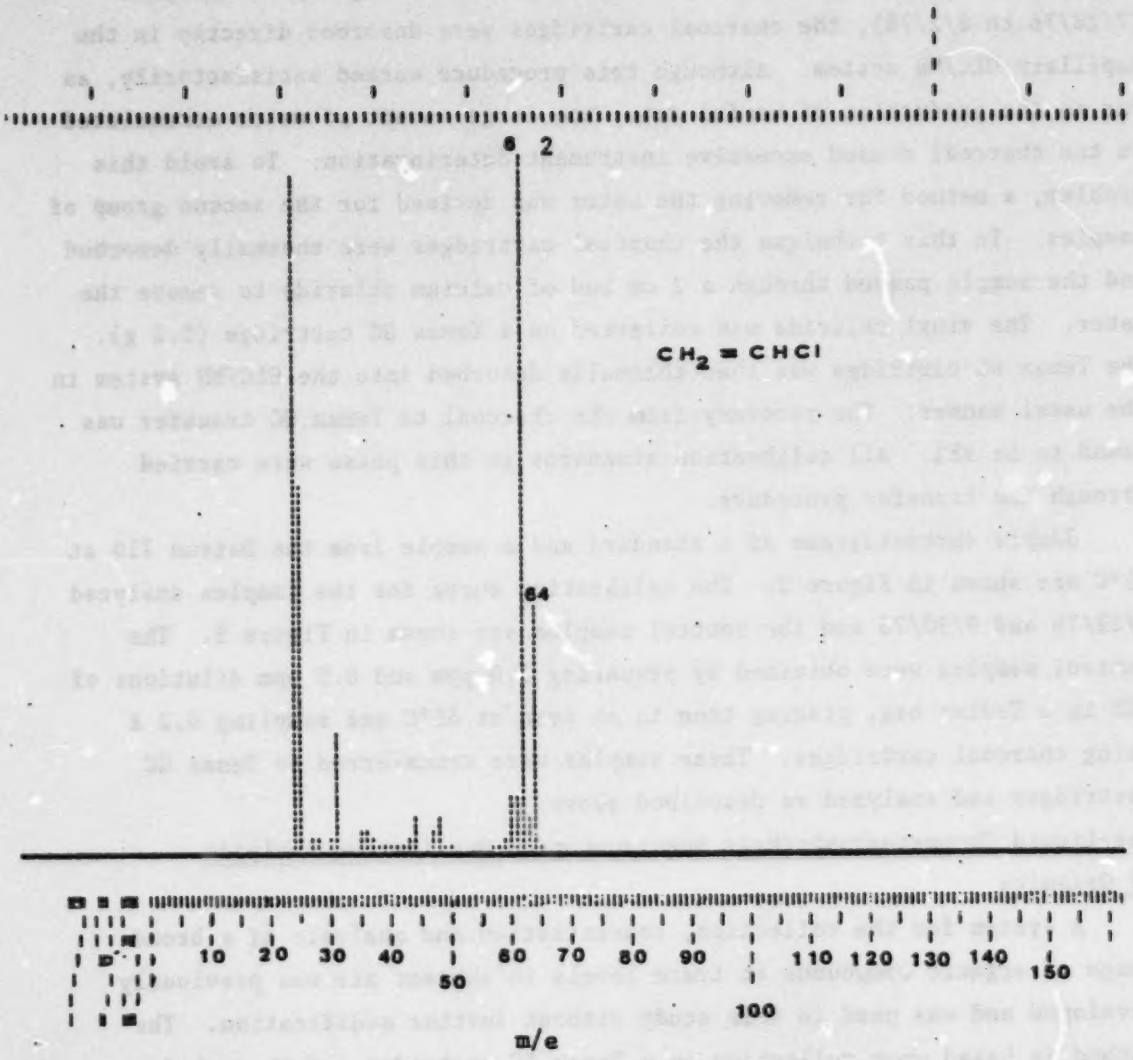

Figure 1. Mass spectrum of a chromatographic peak identified as vinyl chloride monomer from an environmental sample.

Pa.), was used. A cartridge, 6 mm o.d. x 10.5 cm length, was filled with 150 mg of charcoal. The breakthrough volume of this cartridge is ~3 ℓ at 25°C; hence, samples of 0.2 or 0.5 ℓ were well below the breakthrough volume or approximately 3 times that of Tenax. In the first group of analyses (7/28/76 to 8/2/76), the charcoal cartridges were desorbed directly in the capillary GLC/MS system. Although this procedure worked satisfactorily, as far as the production of useful data, the large amount of water accumulated on the charcoal caused excessive instrument deterioration. To avoid this problem, a method for removing the water was devised for the second group of samples. In this technique the charcoal cartridges were thermally desorbed and the sample passed through a 2 cm bed of calcium chloride to remove the water. The vinyl chloride was collected on a Tenax GC cartridge (2.2 g). The Tenax GC cartridge was then thermally desorbed into the GLC/MS system in the usual manner. The recovery from the charcoal to Tenax GC transfer was found to be 95%. All calibration standards in this phase were carried through the transfer procedure.

Sample chromatograms of a standard and a sample from the Datsun 710 at 65°C are shown in Figure 2. The calibration curve for the samples analyzed 9/29/76 and 9/30/76 and the control samples are shown in Figure 3. The control samples were obtained by preparing 1.0 ppm and 0.5 ppm dilutions of VCM in a Tedlar bag, placing them in an oven at 65°C and sampling 0.2 ℓ using charcoal cartridges. These samples were transferred to Tenax GC cartridges and analyzed as described above.

Gas-Liquid Chromatography/Mass Spectroscopic--Qualitative Analysis of Organics

A system for the collection, concentration and analysis of a broad range of organic compounds at trace levels in ambient air was previously developed and was used in this study without further modification. The method is based upon collection on a Tenax GC cartridge and thermal desorption analysis. The thermal desorption technique which is a refinement of Duel's[10] solvent-free sample inlet system has been used at RTI to analyze organics in ambient air (EPA Contract No. 68-02-1228) as well as those in energy-related wastes and effluents (EPA Contract No. 68-03-

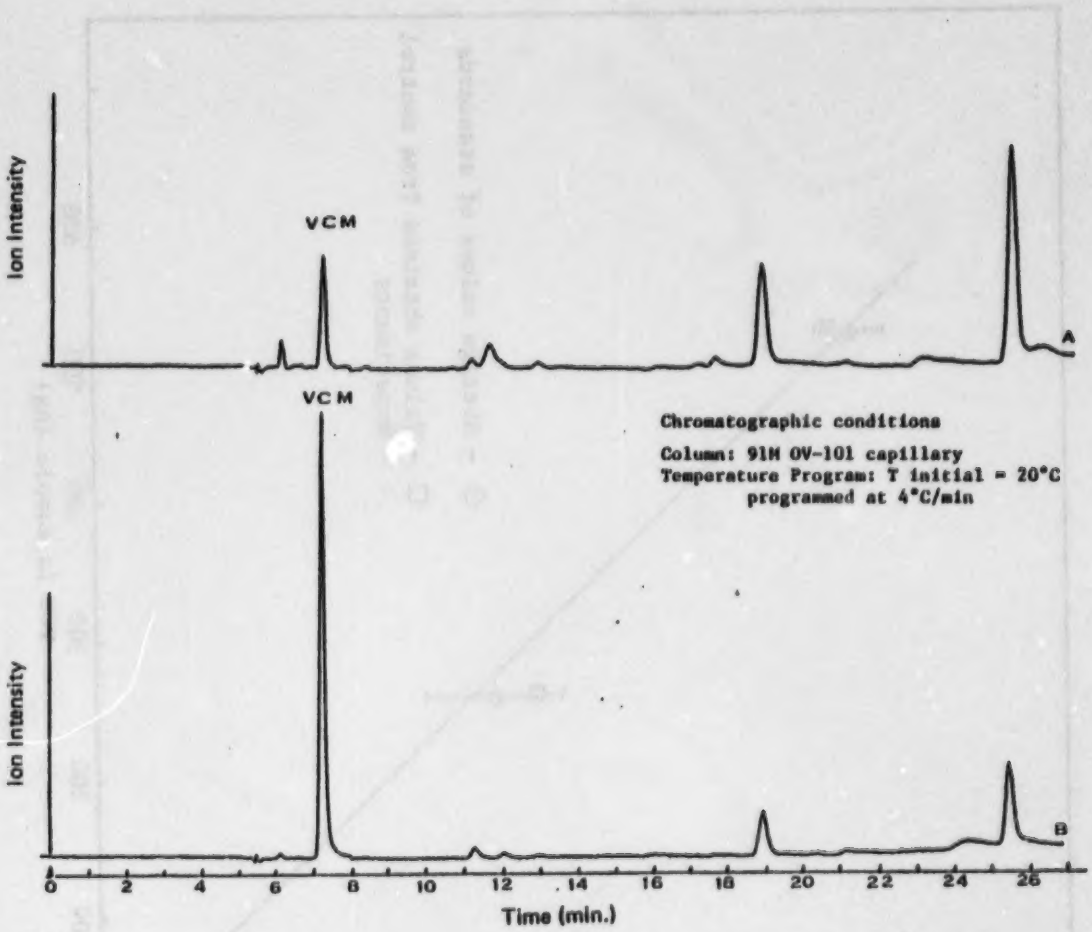

Figure 2. Gas chromatography/mass spectrometric analysis - single ion mode (m/e = 62) of: (a) Air from the interior of a Datsun 710 automobile at 65°C (0.5 ℓ sample), (b) 50 ng standard of VCM.

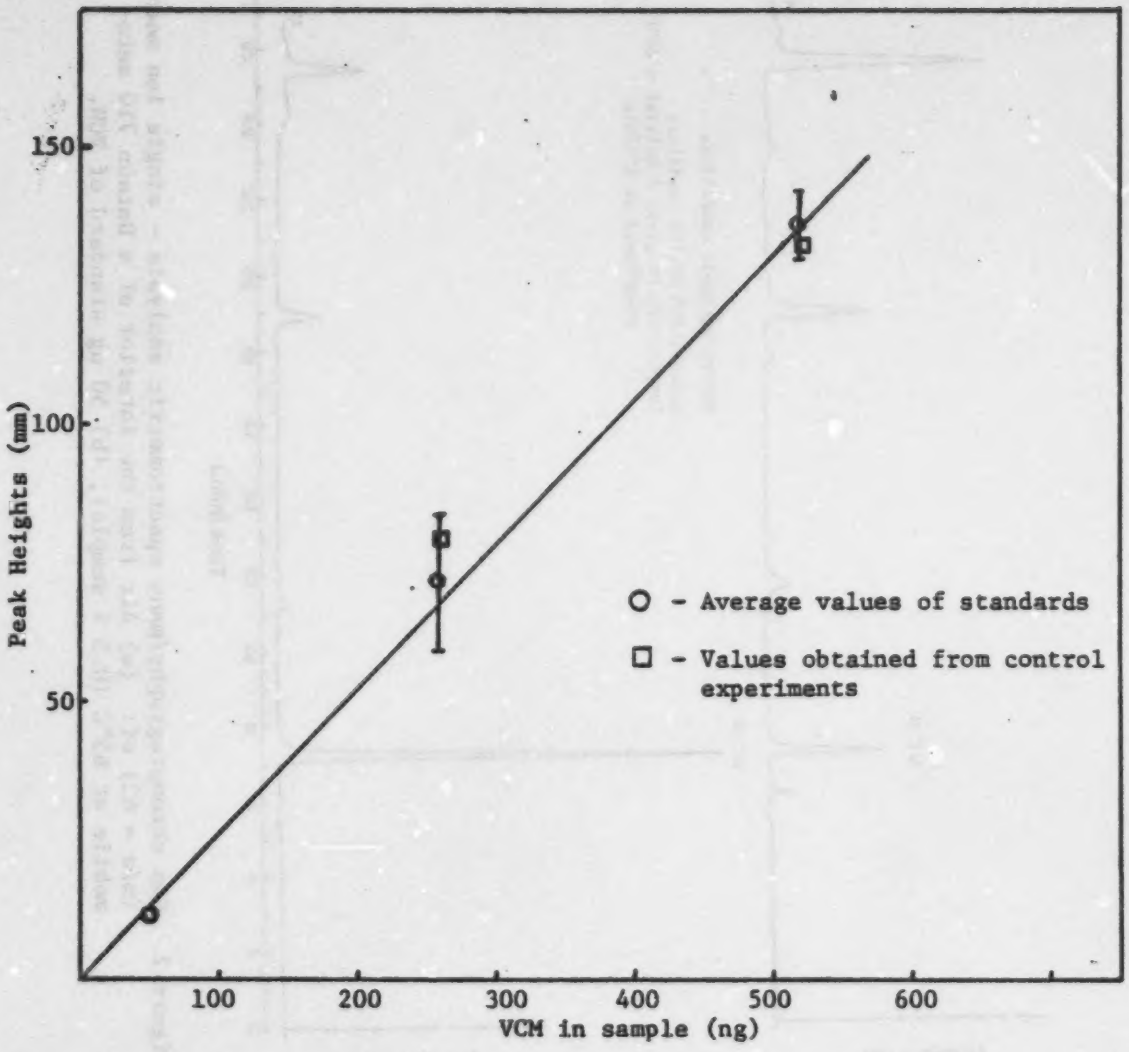

Figure 3. Calibration curve for vinyl chloride monomer.

2368). The system is designed so that the entire sample mixture can be introduced onto the GLC column.

The inlet manifold (Figure 4) for introducing the sample into the instrumental systems consists of four main components: a desorption chamber (Figures 4 and 5); a six-port, two-position, high-temperature low-volume valve; a nickel capillary trap and a temperature controller.

An aluminum sandwich serves as a thermal source. Two heating cartridges are used to heat the aluminum sandwich, and the temperature is monitored and controlled with a platinum sensor probe. The desorbed vapors pass into a six-port, two-position valve which is also encased in an aluminum heating bath. Temperature control is identical to the thermal desorption chamber. The temperature is monitored directly on a pyrometer. Control is ± 1°C.

A nickel capillary constitutes one loop of the valve proper which is cooled with liquid nitrogen and serves as a trap for collecting and concentrating desorbed vapors prior to their introduction into the high-resolution GLC column. The vapors are released from the capillary trap by rapidly heating to 175°C.

The multiport valve used on the inlet manifold was chosen for its polyimide stem to minimize the contact of desorbed trace vapors with reactive metal surfaces, therefore minimizing contamination and/or decomposition of sample constituents.

In a typical thermal desorption cycle, a Tenax GC sampling cartridge containing volatile organics was placed in the preheated (>270°C) chamber, and helium gas was passed through the cartridge (>20 ml/min) to purge the vapors into the liquid-nitrogen-cooled capillary trap. This condition constitutes the valve position A (Figure 4). After the thermal desorption step was completed, the six-port valve was rotated to position B (Figure 4): the temperature on the capillary loop rose rapidly, whereupon the carrier gas carried the vapors onto the high resolution capillary column.

For the identification of volatile organic compounds, the combined technique of gas-liquid chromatography/mass spectrometry/computer (GC/MS/-COMP) was employed. The instrumental outlay is shown in Figure 6.[11] Techniques previously developed by RTI for analysis of hazardous compounds were applied to this research program.

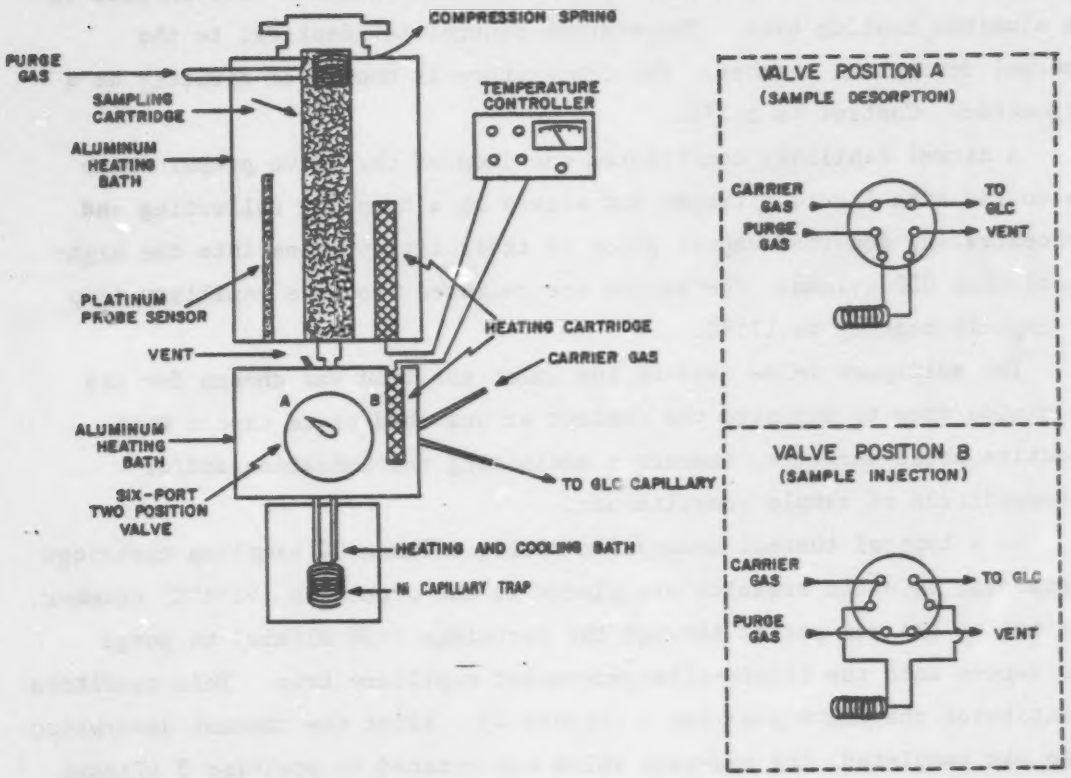

Figure 4. Thermal desorption inlet manifold.

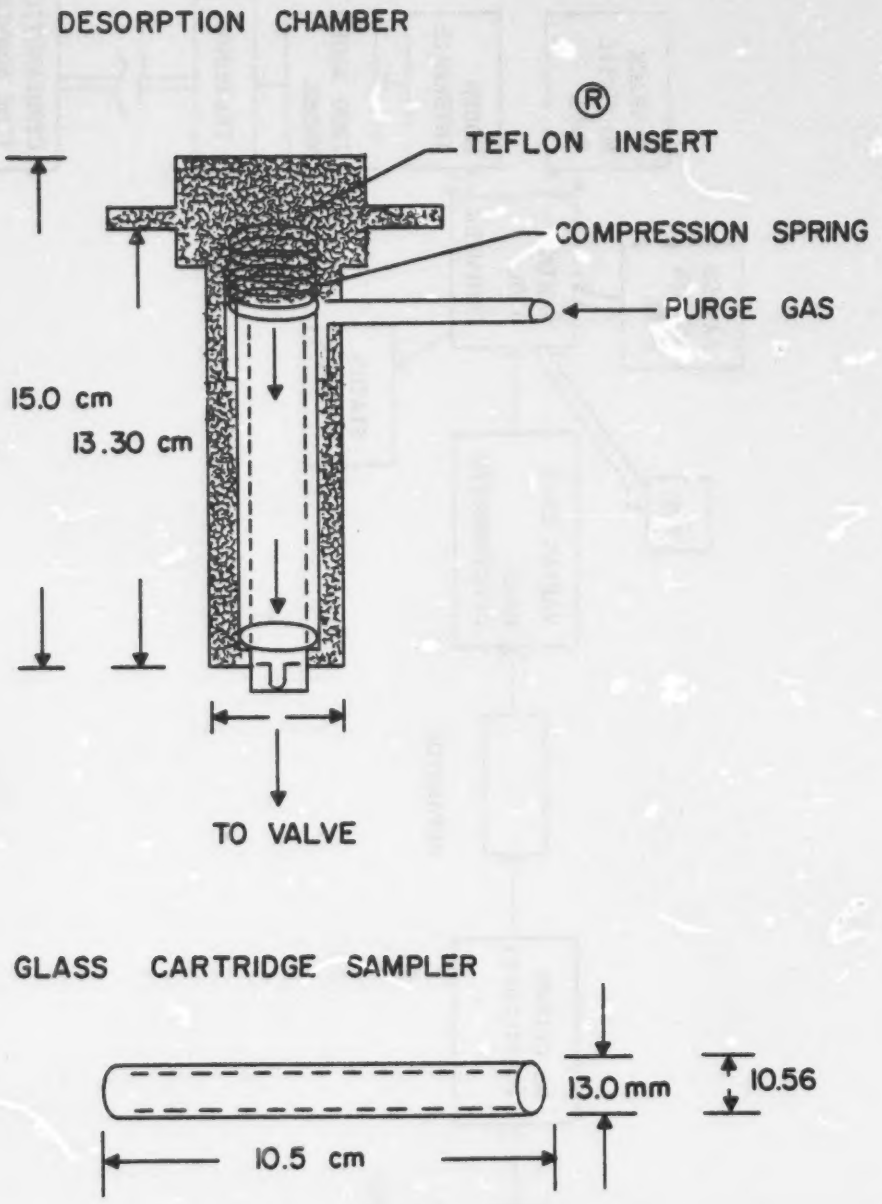

Figure 5. Thermal desorption chamber.

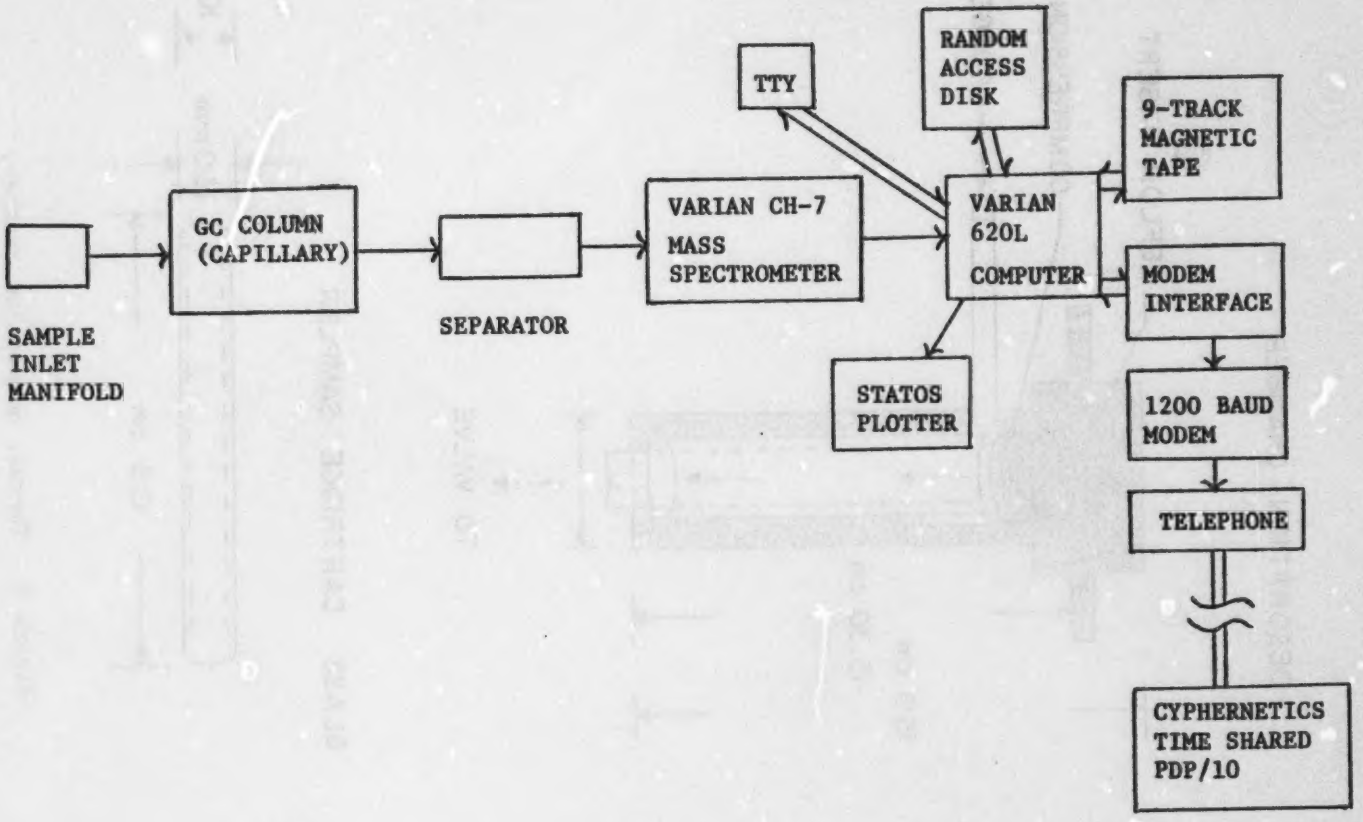

Figure 6. Instrumental outlay of the gas chromatography/mass spectrometry/computer system.

The previously described inlet manifold was used for recovering vapors trapped on Tenax GC cartridges, and it was interfaced to the GLC/MS/COMP system. The desorbed vapors were subsequently resolved by gas-liquid chromatography, and mass cracking patterns were automatically and continuously obtained throughout the GLC run with a Varian CH-7 mass spectrometer. Operating parameters, depicted in Table 2 for the GLC/MS/COMP system are suitable for the volatile organic fraction. Analysis profiles from automobile interiors are included in Appendix B, along with an unabridged list of identified compounds. The high resolution capillary columns are capable of resolving a multitude of compounds to allow their subsequent identification by MS/COMP techniques.

The MS was first set to operate in the repetitive scanning mode. In this mode, the magnet is automatically scanned exponentially upward from preset low mass to high mass values. Although the scan range may be varied depending on the particular sample, typical values would be from m/e 28 to m/e 400. The scan is completed in approximately 5 seconds. At this time the instrument automatically resets itself to the low mass position in preparation for the next scan. The information is accumulated by an on-line 620/L computer on magnetic tapes. The reset period is approximately 2 seconds. Thus, a continuous scan cycle of 7 seconds per scan was maintained. Depending on specific sample requirements, this scan cycle can be shortened to as little as 5 seconds per cycle.

With the magnet continuously scanning, the sample was injected, and automatic data acquisition was initiated. As each spectrum was acquired by the computer, each peak which exceeded a preset threshold was recognized and reduced by centroid time and peak intensity. This information was stored in the computer core while the scan was in progress. In addition, approximately 30 TIC values and an equal number of Hall probe signals were stored in core as they were acquired. During the 2 second period between scans, this spectral information, along with the spectrum number, was written sequentially on magnetic tape, and the computer was reset for the acquisition of the next spectrum.

Table 2. OPERATING PARAMETERS FOR GLC-MS-COMP SYSTEM.

Parameter	Setting
Inlet manifold	
desorption chamber	270°C
valve	180°C
capillary trap - minimum	-195°C
maximum	+175°C
GLC	
200-700 ft SCOT glass capillary columns[a]	20-30°C, 4/C° min
carrier (He) flow	∿3 ml/min
transfer line to ms	210°C
MS	
scan range	m/e 20 → 300
scan rate, automatic-cyclic	1 sec/decade
filament current	300 μA
multiplier	6.0
ion source vacuum	∿ 4×10^{-6} torr

[a] OV-101

This procedure was continued until the entire GC run was completed. By this time, there were from 300 to 1000 spectra on tape, which were then used for subsequent data processing. Depending on circumstances, either the tapes were then be processed immediately, or additional samples run and the results determined later.

The mass spectral data was processed in the following manner. First, the original spectra were scanned, and TIC information extracted. This was done directly from the original tape immediately after data acquisition. Then the TIC intensities were plotted against the spectrum number on the Statos recorder. The information thus gained generally indicated whether or not the run was suitable for further processing, since it gave some idea of the number of unknowns in the sample and the resolution obtained using the particular GLC column conditions.

The next stage of the processing involved the conversion of the spectral peak times to peak masses. To accomplish this, the spectra was read successively into the Varian computer core and then sent at high speed to the PDP/8 disc by means of the intercomputer interface. Depending on the number of peaks in each spectrum, the disc capacity allowed the storage of 200-500 spectra. After the spectra containing time information were stored in the disc, the data was returned to the 620/L for mass conversion and re-stored on magnetic tape. The mass conversion was accomplished by use of the calibration table obtained previously. Normally, one set of calibration data was sufficient for an entire day's processing since the characteristics of the Hall probe are such that the variation was less than 0.2 atomic mass units per day. For very long runs it was necessary to carry out several cycles of mass conversion using the PDP/8 disc to complete the data processing. Time required for the conversion process for 100 spectra was approximately 1 hour.

After the spectra were obtained in mass-converted form, processing proceeded manually. In the manual mode, the full spectra of scans from the GC run were recorded on the Statos plotter. The TIC information available at this time was most useful for deciding which spectra to analyze. At the beginning of the run, where peaks were very sharp, nearly every spectrum was inspected individually. Later in the run, when the peaks were broader, only selected scans were analyzed.

Resolved components were identified by comparing the mass cracking patterns of the unknown mass spectra to an eight major peak index of mass spectra.[12] Searches for individual difficult unknowns, using the Cornell University STIRS and PMB systems were unnecessary. Unknowns may also be submitted to the EPA MSSS system for identification; however, this was not required. When feasible, the identifications may be confirmed by comparing the unknown's cracking pattern and elution temperature on two different columns (OV-17 and OV-101 SCOT capillaries) with authentic compounds; e.g. benzothiazole was compared to an authentic sample. Particular note was made of the boiling point of the identified compounds with the elution temperature and the order of elution of constituents in homologous series, since the OV-101 SCOT capillary separates primarily on the basis of boiling point.

SECTION 5

RESULTS AND DISCUSSION

QUANTITATIVE ANALYSIS OF VINYL CHLORIDE MONOMER

Briefly, the test conditions were an initially ventilated compartment, closed and thermostatically maintained at either 45°C or 65°C for 3 hours before sampling. The results are shown in Table 3 with pertinent information on the automobiles. The quantitation was performed using charcoal cartridges for the collection of 0.2 or 0.5 ℓ air samples. The vinyl chloride was recovered by thermal desorption and analyzed by capillary GLC-MS using single ion detection at m/e = 62. This method is sensitive and selective.

The instrumental operating parameters for the first test sequence (June 29 - July 2, 1976), which included all the domestic automobiles tested, did not permit the detection of VCM at levels below 50 ppb; however, the General Motors Chevette in this group was included in the second test sequence with the imported automobiles where the limit of detection had been lowered to ~2 ppb. Again, VCM was not detected in the Chevette.

QUALITATIVE ANALYSIS OF ORGANIC EMISSIONS

The summarized list of the organics found in the six test automobile interiors is given in Table 4. The list has been prepared by removing compounds found in the background and collating the compounds found in each car to remove redundancies. The combined list was then organized according to structural characteristics for the convenience of evaluating toxicity.

The list of hydrocarbons is long even with the background subtracted and probably represents a significant background due to gasoline evaporative emissions. The background sample was taken outside, next to the Gremlin, in a calm area (protected on two sides).

Table 3. VINYL CHLORIDE MONOMER FOUND IN TEST VEHICLES.

Manufacturer	Model	Description of Upholstery	Temp. (°C)	Date of Manufacture	Sampled	VCM[a] ppb
Ford	Pinto	tan vinyl	45°	6/76	7/30/76	<50
			65°		7/29/76	<50
AMC	Gremlin	blue vinyl	45°	4/76	8/20/76	<50
			65°		7/30/76	<50
GMC	Vega	tan vinyl	45°	7/76	8/02/76	<50
			65°		7/30/76	<50
GMC	Chevette	dark blue vinyl	45°	6/76	7/28/76	<50
			65°		7/28/76	<50
			45°		9/29/76	<2[a]
			65°		9/29-30/76	<2[a]
Nissen Motor Corp.	Datsun 710	black vinyl	45°	5/76	9/29-30/76	3 ± 1[b]
			65°		9/30/76	7 ± 2[a,c]
Volkswagen	Rabbit	black leatherette	45°	7/76	9/29/76	<2[a,c]
			65°		9/29/76	4 ± 3[a,c]

[a]Blanks were all below the limit of detection (2 ppb).

[b]The lowest standard which was analyzed was 40 ppb. The estimates here are obtained by extrapolation of the calibration curve.

[c]Average and standard deviation of duplicate determinations.

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS

Compounds	Notes
Halogenated Compounds	
1,2-dibromoethane (tent.)	a
chlorobutane (tent.)	b
chlorocyclohexanol	b
chlorostyrene (tent.)	b
hexachloroethane (tent.)	b
chloroethylbenzene (tent.)	b
dichlorobenzene isomer	c
trichlorobenzene isomer	d
Oxygen Containing Compounds	
Aldehydes and Ketones	
propenal	e,f
propanal	e,f
2-methylpropanal	e
2-methylpropenal (tent.)	e,f
n-butanal	e,f
3-methylbutanal	e
n-hexanal	e,f
hexanal isomer	f
3-methylbutanal	f
n-heptanal	e
2-butenal	f
ethylbutanal (tent.)	c
methoxybenzaldehyde	b
methyl vinyl ketone	e
methyl ethyl ketone	e
4-methyl-2-pentanone	f
2-heptanone	f
octanone isomer (tent.)	f

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Oxygen Containing Compounds (con.)	
Aldehydes and Ketones (con.)	
cedranone ($C_{15}H_{24}O$) (tent. ?)	c
long chain propyl ketone	c,d
Alcohols	
2-propanol	e
2-methyl-2-propanol	e,a,f
2-methyl-1-propanol	e
1-butanol	e,f
2-methyl-1-butanol (tent.)	f
undecenol (tent.)	d
dimethylphenol isomers	e,a,f,b
ethylphenol isomer	f
cresol	c,b,g
di-t-butyl cresol	b,d
Ethers	
furan	b,f
dimethyl ether	e,f
diethyl ether	e
vinyl methyl ether (tent.)	c,d
ethyl vinyl ether	c
m-cresyl ethyl ether	c,b
diphenyl ether (tent.)	c,d
benzyl phenyl ether (tent.)	c,d
furfuryl methyl ether (tent.)	b
dimethyl-1,4-dioxane (tent.)	b
methyl anisole	b
butyl methyl ether	d
dihydropyran	d
anisole	d

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Oxygen Containing Compounds (con.)	
Ethers (con.)	
diphenoxybenzene	g
methoxyanthracene (tent.)	b
Other	
ethyl acetate	f
maleic anhydride (tent.)	b,g
hexenyl hexenate (tent.)	b
phthalate	g
Nitrogen Containing Compounds	
N-methyl-2-butylamine (tent.)	b
diethylamine (tent.)	b
N-n-butylpiperidine (tent.)	b
butylaminodiphenylamine (tent.)	d
2-amino-2-methyl-1-propanol	g
cyclohexylamine (tent.)	c
aniline	g
trimethylindoline (tent.)	c
phenylindole (tent.)	c
pyridine (tent.)	b
N-ethylpyridine (tent.)	c
phenylpyridine (tent.)	c
dimethylquinoline	d
propene nitrile (tent.)	a
propane nitrile (tent.)	b
3,3-dimethylcyclobutane carbon nitrile (tent.)	g
toluene diisocyanate (tent.)	c
Sulfur Containing Compounds	
carbon disulfide	e,c,b
diethyl sulfide	e
benzothiazole	e,d,g
diisobutylthiophene (tent.)	b d

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Sulfur Containing Compounds (con.)	
C_8-alkyl thiophene (tent.)	d
Aromatic Hydrocarbons	
isopropylbenzene	e,f
n-propylbenzene	e,a,f,c,b,d
1,2,4-trimethylbenzene	e,a,f
o-propyltoluene	e,a
diethylbenzene isomer	e
ethylbenzene	a,f,c
p-xylene	a,f
1,3,5-trimethylbenzene	a
p-propyltoluene	a
C_4-alkyl benzene isomers	e,a,f,c,b,d
C_5-alkyl benzene isomers	e,a,f,c,b,d
dimethylethylbenzene isomers	e,a
tetramethylbenzene isomer	e
p-ethyltoluene	f
biphenylene	c
C_6-alkyl benzene isomers	c,b,d
dimethyldihydroindene or methyltetrahydronaphthalene	c,b,d
C_7-alkyl benzene isomers	c,b,d
unsaturated C_6-alkyl benzene isomers	c
unsaturated C_7-alkyl benzene isomers	c
C_9-alkyl benzene isomer	c
biphenyl	c,b,g
unsaturated C_8-alkyl benzene isomer	c
trimethylisopropylbenzene	b
phenylcyclohexene	b
C_8-alkyl benzene	d
methylstyrene isomers	c,b,d

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Aromatic Hydrocarbons (con.)	
dimethylstyrene	a,d
C_2-alkyl styrene isomers	c
diethylstyrene isomers	b
di-t-butylphenanthrene (tent.)	g
dimethylindane	b,d
naphthalene	e,c,b
methyltetrahydronaphthalenes	c,b
dimethylnaphthalene	c,b,d,g
dimethyldihydronaphthalenes	c
tetrahydronaphthalene	b
ethyltetrahydronaphthalene	b
C_4-alkyl tetrahydronaphthalene	b
dimethyltetrahydronaphthalene	d
Other Hydrocarbons	
C_3	
propene (tent.)	b
C_4	
1-butene	e,a,f,c,b,d
2-butene	a,b,c
n-butane	a,f,c,d
C_4H_{10} isomer	c
C_5	
n-pentane	a,f,b,d
cyclopentene	a
pentyne	b
C_5H_{10} isomer	c

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Other Hydrocarbons (con.)	
C_6	
C_6H_{10} isomers	e,a,b,d
methylpentene	a
C_7	
C_7H_{12}	b
methyl hexyne	g
methyl cyclohexene isomers	a
C_8	
C_8H_{16} isomers	e,f,b,d
ethylcyclohexane	e
trimethylpentane isomer	a
C_8H_{14} isomers	a,b
C_9	
C_9H_{16} isomers	e,f,c,b,d
C_9H_{18} isomers	e,f,c,b,d
trimethylcyclohexane	e
2,3-dimethylheptane	e
propylcyclohexane	e,f,b
C_{10}	
$C_{10}H_{22}$ isomers	e,a,b
$C_{10}H_{18}$ isomers	e,f,c,b
$C_{10}H_{16}$ isomers	e,f,b
butylcyclohexane	e,f,b,d
terpinene isomers	e,a,f,c,b,d
$C_{10}H_{12}$ isomer	a
$C_{10}H_{20}$ isomers	e,f

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Other Hydrocarbons (con.)	
C_{11}	
$C_{11}H_{22}$ isomers	e,a,f,c,b,d
$C_{11}H_{20}$ isomers	a,f,c,b,d
pentylcyclohexane	e,f
C_{12}	
$C_{12}H_{26}$ isomers	e,f,c,b,d
$C_{12}H_{24}$ isomers	e,f,c,b,d
n-dodecane	e,f
triisobutylene	f
$C_{12}H_{16}$ isomers	c
$C_{12}H_{22}$ isomers	b,d
$C_{12}H_{18}$ isomer	b
hexylcyclohexane	e
C_{13}	
$C_{13}H_{28}$ isomers	e,f,c,b,d
$C_{13}H_{26}$ isomers	e,a,f,c,b,d
2-methyldodecane	e
3-methyldodecane	e
3-methyldodecane	e
n-tridecane	e
$C_{13}H_{24}$ isomers	c,b,d
dodecahydrofluorene (tent.)	d
C_{14}	
$C_{14}H_{30}$ isomers	e,c,b,d
$C_{14}H_{28}$ isomers	e,c,b,d
$C_{14}H_{26}$ isomers	c,b

Table 4. ORGANICS FOUND IN AUTOMOBILE INTERIORS (con.)

Compounds	Notes
Other Hydrocarbons (con.)	
C_{14} (con.)	
$C_{14}H_{24}$ isomers	c
$C_{14}H_{22}$ isomers	c
C_{15}	
$C_{15}H_{32}$ isomers	c,b,d
$C_{15}H_{30}$ isomers	d,c,b
$C_{15}H_{28}$ isomers	c,b
$C_{15}H_{26}$ isomers	c
$C_{15}H_{24}$ isomers	c,b
$C_{15}H_{22}$ isomers	b
C_{16}	
$C_{16}H_{34}$ isomers	c,b,d
$C_{16}H_{32}$ isomers	c,b,d
$C_{16}H_{28}$ isomers	b
$C_{16}H_{30}$ isomers	b
C_{17}	
$C_{17}H_{36}$ isomers	b,c

Notes:

a = Compound found in 1976 Datsun - 9/24/76
b = Compound found in 1976 Gremlin - 7/30/76
c = Compound found in 1976 Pinto - 7/29/76
d = Compound found in 1976 Vega - 8/5/76
e = Compound found in 1976 Rabbit - 9/22/76
f = Compound found in 1976 Chevette - 9/13/76
g = Compound found in 1976 Chevette - 7/28/76

In the test procedure the automobiles were ventilated to outside air, closed up in the normal manner and the interior temperature thermostated at 65°C. After 3 hours, samples of the interior air were collected on Tenax cartridges and analyzed by GC/MS.

Some identifications are reported as tentative. This usually means that the sample spectrum fits the reference compendium data for that identification, but is equivocal due to the presence of background, other unresolved components or an insufficient amount of the component.

Empirical formulae are reported for many hydrocarbons with occasional further designation of branched or normal. The hydrocarbons reported as empirical formulae could be expanded only in a few instances to indicate that they were branched (the normal isomers appeared in the background). Structural elucidation beyond this point is complicated by two factors: (1) hydrocarbon isomers having the same empirical formula result in the same array of m/e values with relative intensities being the only distinguishing feature; and (2) compendia of mass spectra do not list all isomers, especially as the molecular weight and number of isomers increase. This situation is further complicated by incomplete chromatographic separation of hydrocarbons and several hydrocarbons giving rise to the same ions. Such overlap can seriously affect the relative intensities and can make this an unreliable parameter for structural identification. Greater mass spectral resolution does nothing to solve this problem since the "interferent" gives rise to the same ion(s).

Quantitatation of the organics was not included in the scope of work. Although information on specific compounds may be retrieved for the Datsun, Rabbit and Chevette, this would be a project in itself. However, comparing the number and size of peaks in the Datsun chromatogram with the perfluorobenzene external standard, shows the total concentration of organics to be about 1-10 μg/ℓ. The other automobiles were not sufficiently different for this type of estimate not to apply to them. On the other end of the scale, approximately 1 ng/ℓ or more would have to be present for an identification to be made.

A frequency prioritized list of the same compounds is included in Appendix C to facilitate inspection of the most commonly found compounds.

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12. Eight Peak Index of Mass Spectra. Vol. I (Tables 1 and 2) and II (Table 3), Mass Spectrometry Data Centre, AWRE, Aldermaston, Reading, RG74PR, UK, 1970.

APPENDIX A

SAMPLING PROCEDURE

APPENDIX A
SAMPLING PROCEDURE

Two design criteria were essential to the sampling of the interior of each automobile. One was to be able to withdraw an air sample from the compartment without adversely affecting the breakthrough volume of the sorbent used in sampling. The other was to control the temperature of the compartment. The experimental arrangement which was used to meet these requirements is discussed below.

SAMPLING PORT

A Plexiglas panel was designed to enable the sampling cartridges to be inserted into the automobile window. A grooved edge on the panel allowed it to fit snugly over the window glass, with the upper edge inserted into the groove normally accepting the window glass. The areas not covered by this panel were sealed using heavy weight aluminum foil supported with cardboard. The foil extended beyond the opening to cm and was pressed to conform to the window contours. This covering was held in place with duct tape applied at intervals along the perimeter. (see Figure A-1). Two ports were drilled in the panel: one 16 mm in diameter for the Tenax cartridge; the other 6 mm in diameter for the charcoal cartridge. When not in use these were filled with an aluminum foil plug.

TEMPERATURE CONTROLS

The temperature of the automobile interior was positvely controlled using the arrangement shown schematically in Figure A-2. The temperature

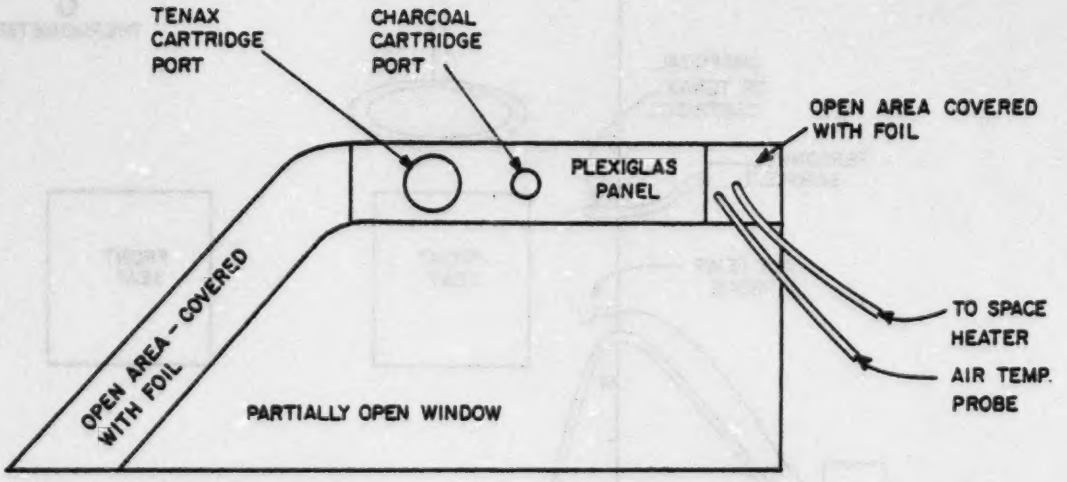


Figure A-1. Side window on driver's side.

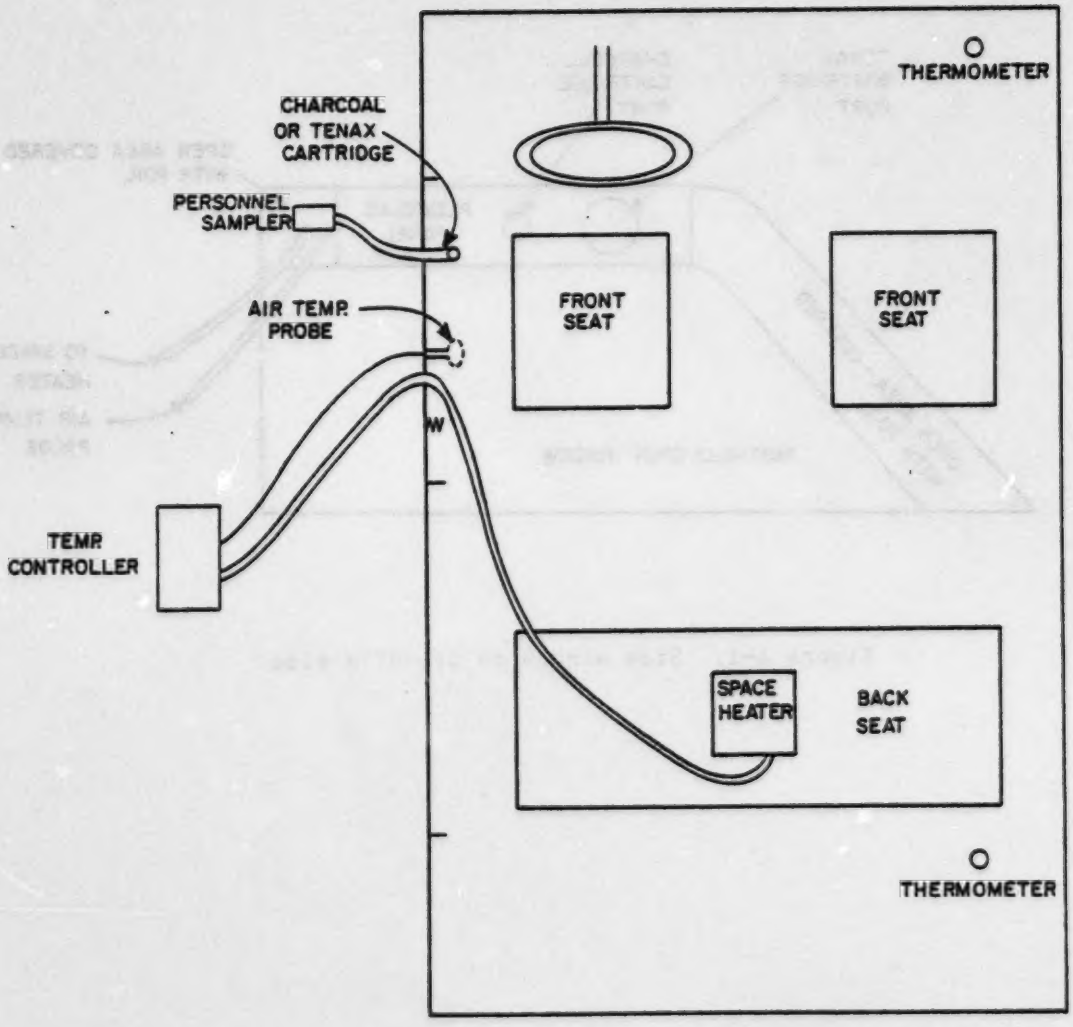


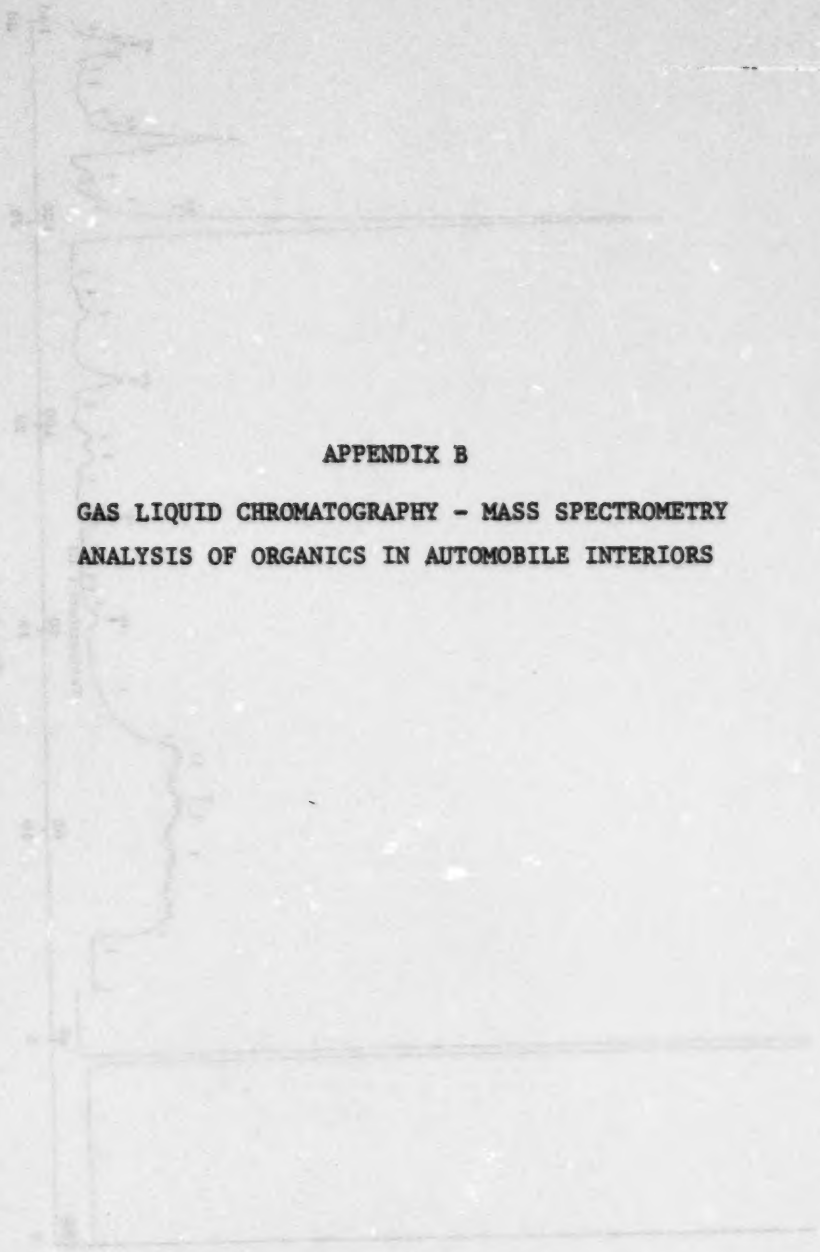
Figure A-2. Automobile interior temperature control.

monitored at two points in the front and back of the compartment was found to be constant within ±2°C. The desired temperature was maintained for 3 hours before initiating the sample collection. The 200 to 500 ml samples collected on SKC charcoal were collected at 50 ml/min for 4 and 10 minutes, respectively. The Tenax GC samples were collected at 100-300 ml/min for 1 to 2 hours. Samples were collected using either a DuPont constant-flow personnel sampler (Pinto, Gremlin, Vega, and Chevette [1st sequence]) or an SKC personnel sampler (Chevette [2nd sequence], Datsun and Rabbit). Air was pulled through a cartridge which protruded just inside the car when placed in the Plexiglas sampling port (see Figure A-1). The cartridge was attached to the sampler by a short rubber tube. The charcoal cartridge consisted of 150 mg of SKC Lot 104 charcoal packed between two 1 cm glass wool plugs inside a glass tube 6 mm o.d. The Tenax cartridge consisted of an 8 cm length of Tenax GC packed between two 1 cm glass wool plugs inside a glass tube 16 mm o.d. All cartridge samples were sealed in culture tubes and stored at or below -5°C until analyzed.

The sampling arrangement used here minimized the effect of the elevated temperature of the automobile interior on the cartridge temperature and consequently maintained the breakthrough volume. Since the cartridges were outside the car, they remained at ambient temperature until sampling was initiated. The low flow rates used for sampling minimized the temperature rise due to the temperature of the air sampled.

APPENDIX B

GAS LIQUID CHROMATOGRAPHY - MASS SPECTROMETRY ANALYSIS OF ORGANICS IN AUTOMOBILE INTERIORS



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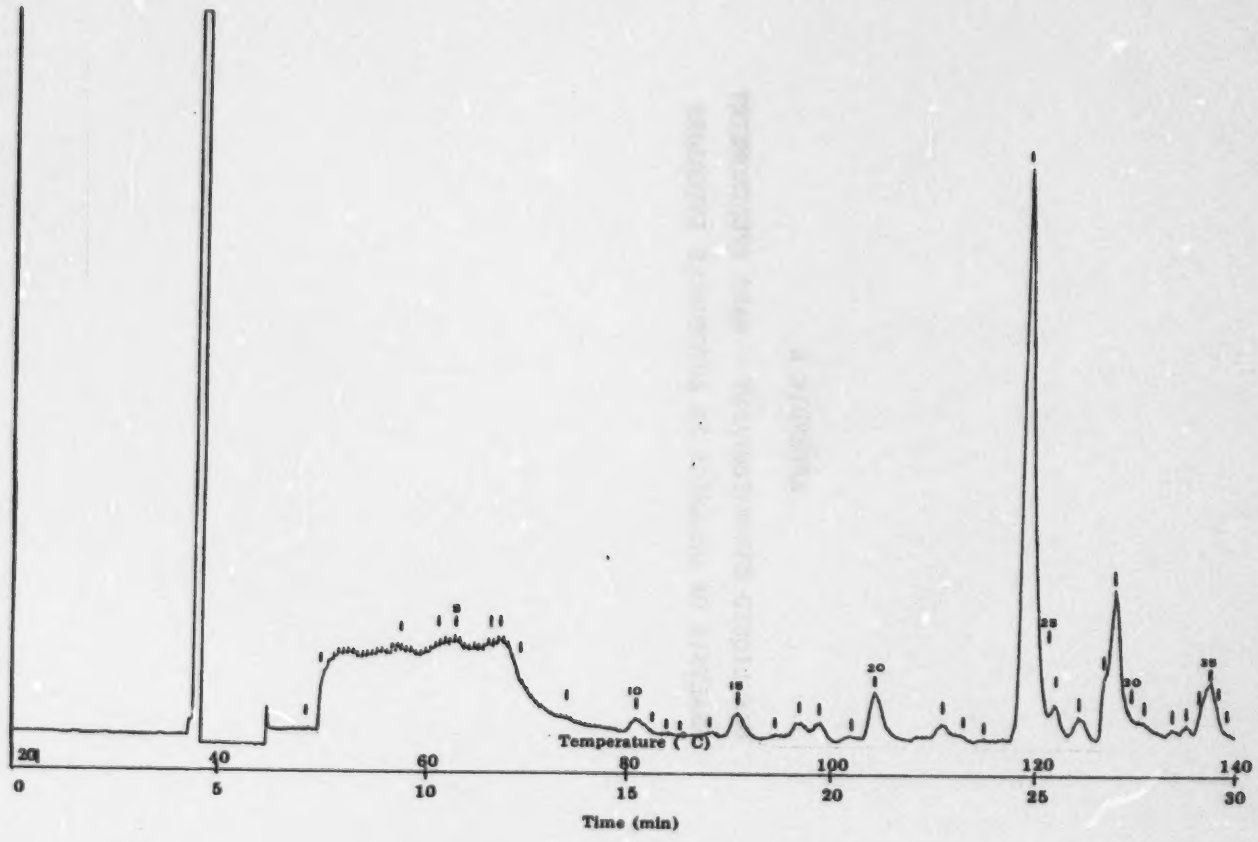

Figure B-1. Total ion current plot during gas liquid chromatography/mass spectrometry of air sample from the interior of a Vega (8/26/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 31.6 ℓ.

(con.)

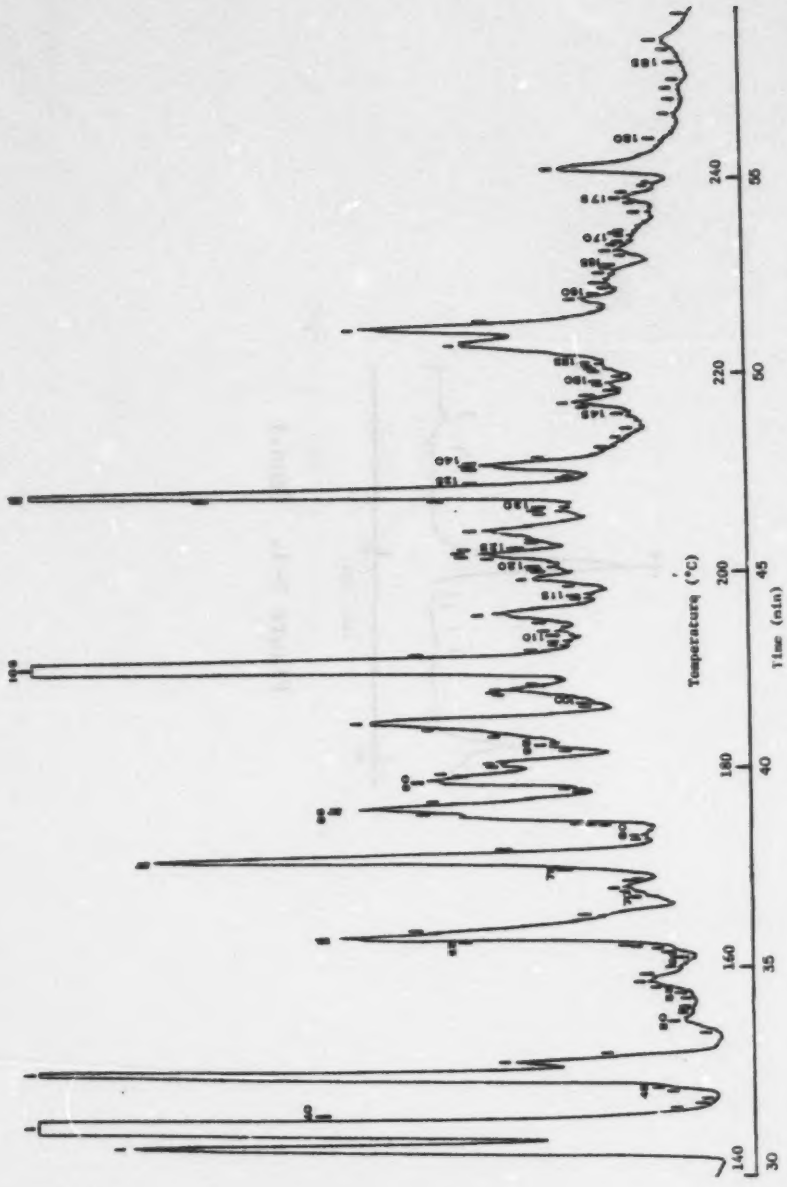

Figure B-1. (con.)

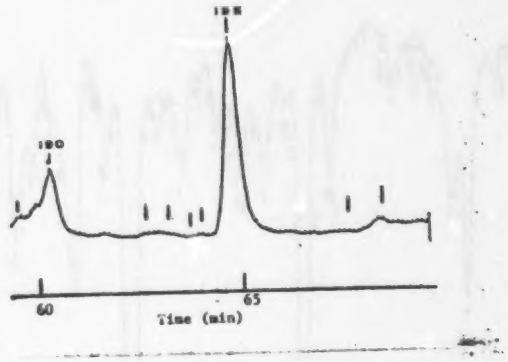

Figure B-1. (con.)

Table B-1. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-1.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	48	acetaldehyde
2	50	butene
3	57	C_4H_{10} isomer
4	62	C_5H_{12} isomer
5	63	C_5H_{12} isomer
6	66	C_7H_{14} isomer
7	66	vinyl methyl ether (tent.)
8	70	methyl butyl ether
9	74	C_6H_{14} isomer
10	81	C_6H_{14} isomer
11	83	$CHCl_3$
12	84	C_6H_{10} isomer
13	86	C_6H_{12} isomer
14	88	C_6H_{12} isomer
15	90	1,1,1-trichloroethane
16	94	benzene
17	97	C_7H_{16} isomer
18	98	C_7H_{16} isomer
19	102	C_7H_{14} isomer
20	104	C_7H_{16} isomer
21	111	C_7H_{14} isomer
22	112	C_8H_{18} isomer
23	114	C_8H_{16} isomer
24	119	toluene
25	120	C_8H_{18} isomer
26	122	C_8H_{16} isomer
27	124	C_8H_{16} isomer
28	126	C_8H_{18} isomer
29	128	C_8H_{16} isomer
30	129	C_8H_{16} isomer
31	130	tetrachloroethylene
32	134	hexamethylcyclotrisiloxane (BKG)
33	135	C_9H_{20} isomer
34	136	C_8H_{16} isomer
35	137	C_9H_{18} isomer
36	138	C_9H_{18} isomer
37	139	dihydropyran
38	141	ethylbenzene
39	142	m/p-xylene
40	144	C_9H_{20} isomer
41	145	C_9H_{20} isomer
42	146	C_9H_{18} isomer
43	146	C_9H_{16} isomer
44	147	styrene
45	147	C_9H_{18} (cyclooctatetraene (tent.)
46	148	o-xylene
47	150	C_9H_{18} isomer
48	151	C_9H_{20} isomer
49	153	anisole
50	154	C_9H_{18} isomer
51	155	$C_{10}H_{22}$ isomer
52	155	C_3-benzene
53	156	$C_{10}H_{20}$ isomer
54	157	C_9H_{18} isomer
55	157	C_9H_{16} isomer
56	158	$C_{10}H_{22}$ isomer
57	158	C_9H_{18} isomer
58	159	$C_{10}H_{20}$ isomer
59	160	pinene
60	161	$C_{10}H_{20}$ isomer
61	161	$C_{10}H_{20}$ isomer
62	162	n-propylbenzene
63	162	$C_{10}H_{18}$ isomer
64	162	$C_{10}H_{22}$ isomer
65	162	$C_{10}H_{22}$ isomer
66	163	phenol
67	163	C_3-benzene
68	164	$C_{10}H_{22}$ isomer
69	165	$C_{10}H_{20}$ isomer
70	166	methyl styrene
71	167	$C_{11}H_{24}$ isomer
72	168	chlorostyrene (tent.)
73	168	$C_{10}H_{20}$ isomer
74	168	$C_{10}H_{18}$ isomer (tent.)
75	170	C_3-benzene
76	171	$C_{10}H_{22}$ isomer
77	171	$C_{10}H_{20}$ isomer
78	172	$C_{10}H_{20}$ isomer
79	173	dichlorobenzene (tent.)
80	173	C_4-benzene
81	175	$C_{11}H_{22}$ isomer
82	175	$C_{11}H_{24}$ isomer
83	175	t-butoxyethanol
84	176	C_4-benzene
85	176	C_4-benzene
86	176	$C_{11}H_{24}$ isomer
87	177	C_4-benzene
88	178	terpinene
89	178	C_5-benzene
90	179	dipropylbenzene
91	179	$C_{11}H_{22}$ isomer
92	180	C_4-benzene

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Table B-1. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
93	180	$C_{11}H_{22}$ isomer
94	182	$C_{11}H_{24}$ isomer
95	183	$C_{11}H_{22}$ isomer
96	183	$C_{12}H_{26}$ isomer
97	184	C_4-benzene
98	184	$C_{12}H_{24}$ isomer
99	186	Isopropyl methyl phenyl chloride (tent.)
100	186	dimethoxybenzene
101	188	dimethylstyrene
102	188	$C_{11}H_{20}$ isomer
103	188	$C_{11}H_{22}$ isomer
104	188	$C_{11}H_{22}$ isomer
105	190	$C_{11}H_{24}$ isomer (branched)
106	192	C_5-benzene
107	192	$C_{11}H_{22}$ isomer
108	193	$C_{12}H_{24}$ isomer
109	193	C_5-benzene
110	194	$C_{12}H_{26}$ isomer
111	194	$C_{12}H_{24}$ isomer
112	195	C_5-benzene
113	196	$C_{12}H_{26}$ isomer
114	197	C_5-benzene
115	197	$C_{12}H_{24}$ isomer
116	198	C_5H_9-benzene
117	199	pentachloroacetone (tent.)
118	200	$C_{12}H_{22}$ isomer
119	200	$C_{12}H_{24}$ isomer
120	200	$C_{12}H_{26}$ isomer
121	201	C_5-benzene
122	202	$C_{13}H_{26}$ isomer
123	202	$C_{12}H_{24}$ isomer
124	202	$C_{12}H_{26}$ isomer
125	202	$C_{12}H_{24}$ isomer
126	203	$C_{12}H_{26}$ isomer
127	204	$C_{13}H_{28}$ isomer
128	206	$C_{12}H_{24}$ isomer
129	206	trichlorobenzene
130	206	C_6-benzene
131	207	methyltetrahydronaphthalene
132	208	$C_{12}H_{26}$ isomer
133	208	naphthalene
134	208	$C_{12}H_{24}$ isomer
135	209	C_6-benzene
136	210	$C_{13}H_{26}$ isomer
137	210	methyltetrahydronaphthalene
138	211	$C_{13}H_{24}$ isomer
139	211	$C_{13}H_{26}$ isomer
140	211	$C_{13}H_{28}$ isomer
141	211	C_6-benzene
142	212	$C_{13}H_{26}$ isomer
143	214	dimethyltetrahydronaphthalene
144	215	C_6-benzene
145	216	benzothiazole
146	217	$C_{13}H_{26}$ isomer
147	218	C_6H_{11}-benzene
148	218	C_7-benzene
149	219	$C_{14}H_{28}$ isomer
150	219	$C_{14}H_{30}$ isomer
151	220	$C_{13}H_{26}$ isomer
152	221	$C_{14}H_{30}$ isomer
153	221	C_7-benzene
154	221	$C_{13}H_{26}$ isomer
155	221	dimethylindan
156	223	undecenol (tent.)
157	224	$C_{13}H_{28}$ isomer
158	225	$C_{14}H_{28}$ isomer
159	227	μ-naphthalene
160	228	$C_{14}H_{28}$ isomer
161	229	$C_{15}H_{30}$ isomer
162	229	C_7-benzene
163	230	α-methylnaphthalene
164	230	dimethyltetrahydronaphthalene
165	230	C_7-benzene
166	232	dimethyltetrahydronaphthalene
167	232	C_8-benzene
168	233	$C_{14}H_{28}$ isomer
169	234	$C_{15}H_{30}$ isomer
170	234	C_7-benzene
171	234	$C_{14}H_{26}$ isomer
172	234	$C_{14}H_{28}$ isomer
173	236	$C_{16}H_{32}$ isomer
174	238	$C_{15}H_{32}$ isomer
175	238	$C_{15}H_{30}$ isomer
176	238	$C_{16}H_{34}$ isomer
177	239	$C_{14}H_{30}$ isomer
178	239	$C_{15}H_{30}$ isomer
179	240	octamethyltrisiloxane
180	a	$C_{15}H_{30}$ isomer
181	a	dimethylnaphthalene
182	a	$C_{16}H_{34}$ isomer
183	a	dimethylphthalate

Table B-1. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
184	a	dimethylnaphthalene
185	a	$C_{15}H_{30}$ isomer
186	a	dimethylquinoline
187	a	unknown
188	a	$C_{16}H_{32}$ isomer
189	a	$C_{15}H_{32}$ isomer
190	a	di-t-butylcresol
191	a	C_8-thiophene (tent.)
192	a	octamethyltrisiloxane
193	a	diphenylether (tent.)
194	a	long chain propyl ketone
195	a	phenyl tolyl ether
196	a	butylaminodiphenylamine (tent.)

a = Isothermal

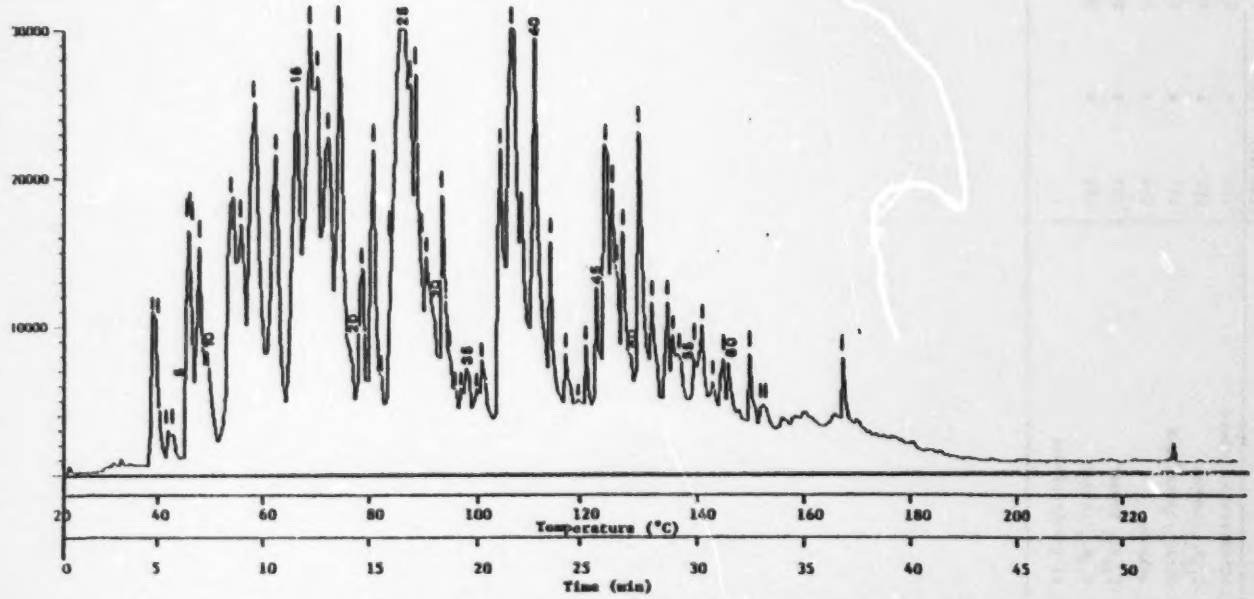

Figure B-2. Total ion current plot during gas liquid chromotography/mass spectrometry of air sample from the interior of a Datsun (10/10/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 18.3 ℓ.

Table B-2. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-2.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	39	CO_2
2	41	difluordichloromethane
2A	41	1-butene
3	42	n-butane
4	42	2-butene
4A	44	C_5H_{10} isomer
5	43	isopentane
6	46	trichlorofluormethane
7	46	C_5H_{10} isomer
8	47	n-pentane
9	48	C_5H_{10} isomer
10	50	acetone
10A	50	propene nitrile (tent.) + freon 113 + CS_2
10B	52	ter-butanol
10C	52	cyclopentene
10D	53	C_6H_{12} isomer
11	54	2-methylpentane
12	56	3-methylpentane
12A	57	C_6H_{12} isomer
13	58	n-hexane + hexafluorobenzene (ex)
13A	59	C_7H_{16} isomer
13B	59	C_6H_{12} isomer
13C	60	C_6H_{10} isomer
13D	61	methylpentene
14	61	methylcyclopentane
14A	62	perfluorotoluene + C_7H_{16} isomer (ex)
14B	63	1,2-dichloroethane
14C	65	C_6H_{10} isomer
15	65	benzene
15A	67	cyclohexane
16	68	2-methylhexane
17	69	2,3-dimethylpentane
17A	70	3-methylhexane
18	71	dimethylcyclopentane isomer
18A	72	trimethylpentane isomer
18B	73	C_7H_{14} isomer
18C	73	C_7H_{12} isomer
19	74	n-heptane
19A	75	C_7H_{14} isomer
20	76	C_7H_{12} isomer
20A	76	methylcyclohexene isomer
21	78	methylcyclohexane
21A	79	C_8H_{16} isomer
22	80	C_8H_{18} isomer
22A	81	C_8H_{18} isomer
23	82	trimethylcyclopentane isomer
23A	82	C_8H_{16} isomer
24	83	C_8H_{14} isomer
24	83	trimethylpentane isomer
25	84	toluene
25A	87	2,3-dimethylhexane
26	87	2,3-dimethylhexane
27	88	3-methylheptane
28	89	C_8H_{16} isomer
29	90	C_9H_{20} isomer
29A	91	1,2-dibromoethane (tent.)
30	92	C_8H_{16} isomer
30A	92	C_8H_{14} isomer
31	93	n-octane
31A	94	C_8H_{16} isomer
32	95	C_8H_{14} isomer
33	97	C_9H_{20} isomer
34	98	silane compound (BKG)
35	98	C_9H_{20} isomer
36	100	ethylcyclohexane
36A	101	C_9H_{20} isomer
37	102	C_9H_{18} isomer
37A	103	C_9H_{18} isomer
38	104	ethylbenzene
39	106	p-xylene
39A	108	C_9H_{20} isomer
40	111	o-xylene
40A	113	C_9H_{18} isomer
41	114	n-nonane
41A	117	C_9H_{18} isomer
42	117	isopropylbenzene
42A	117	$C_{10}H_{22}$ isomer
43	119	$C_{10}H_{22}$ isomer
43A	120	$C_{10}H_{20}$ isomer
44	121	terpinene isomer
44A	121	$C_{10}H_{22}$ isomer
45	122	n-propylbenzene
46	123	p-ethyltoluene
47	125	1,3,5-trimethylbenzene
48	126	$C_{10}H_{22}$ isomer
48A	126	phenol (tent.)
49	127	o-ethyltoluene
50	128	$C_{10}H_{20}$ isomer
51	130	1,2,4-trimethylbenzene
52	132	n-decane

Table B-2. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
52A	133	$C_{10}H_{20}$ isomer
52B	134	C_4-alkyl benzene isomer
53	135	1,2,3-trimethylbenzene
53A	135	C_4-alkyl benzene isomer
54	136	$C_{11}H_{24}$ isomer
55	137	methylstyrene + $C_{11}H_{24}$ isomers
55A	138	$C_{10}H_{20}$ isomer
55B	139	C_4-alkyl benzene isomer
56	140	p-propyltoluene
57	141	n-butylbenzene + propyltoluene
58	143	o-propyltoluene
58A	143	$C_{11}H_{24}$ isomer
59	145	dimethyl ethylbenzene isomer
60	146	dimethylstyrene or $C_{10}H_{20}$ isomer
60A	147	C_4-alkyl benzene isomer
60B	148	$C_{11}H_{22}$ isomer
60C	149	C_4-alkyl benzene isomer
61	150	n-undecane
62	152	C_4-alkyl benzene isomer
63	153	C_4-alkyl benzene isomer
63A	153	$C_{11}H_{20}$ isomer
63B	156	$C_{10}H_{12}$ isomer
63C	156	C_5-alkyl benzene isomer
63D	158	$C_{10}H_{12}$ isomer
63E	159	dimethylphenol + C_4-alkyl benzene isomer
63F	159	C_5-alkyl benzene isomer
63G	161	$C_{12}H_{24}$ isomer
63H	166	$C_{12}H_{24}$ isomer
64	167	n-dodecane
64A	173	$C_{13}H_{26}$ isomer

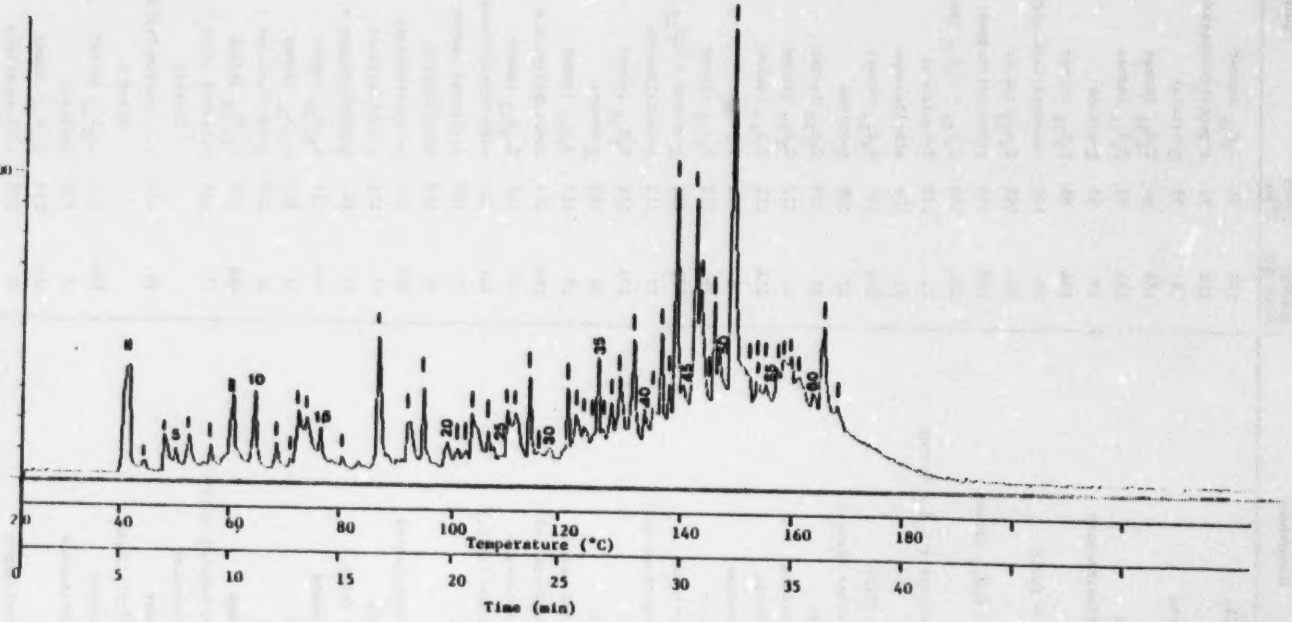

Figure B-3. Total ion current plot during gas liquid chromotography/mass spectrometry of air sample from the interior of a Chevette (10/10/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 13.3 ℓ.

Table B-3. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-3.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
2	40	CO_2 + CF_2Cl_2
3	43	1-butene
3A	43	acetaldehyde
3B	44	n-butane
4	47	isopentane
4A	47	trichlorofluormethane
4B	48	1-pentene
4C	48	2-pentene + furan
5	49	n-pentane
5A	49	propanal + C_5H_{10} isomer
5B	50	propenal
5C	50	dichloromethane + C_5H_{10} isomer
6	51	acetone
6A	51	freon 113 (BKG)
6B	53	dimethyl ether (tent.)
6C	54	ter-butanol
7	55	2-methylpentane
7A	56	crotonaldehyde
7B	57	3-methylpentane
7C	57	C_6H_{12} isomer
7D	58	2-methylpropanal
8	59	hexafluorobenzene (eE)
9	59	n-hexane
9A	60	chloroform
9B	61	methyl ethyl ketone
10	64	perfluorotoluene (eE)
10A	65	methylcyclopentane
10B	66	ethyl acetate (tent.)
11	67	n-butanal
12	69	benzene
12A	69	carbon tetrachloride
12B	70	cyclohexane
12C	71	1-butanol (tent.)
13	72	2-methylhexane
14	73	3-butanal
15	76	n-heptane
15A	78	C_8H_{16} isomer
16	79	2-methyl-1-butanol (tent.)
16A	80	methylcyclohexane
16B	82	C_8H_{18} isomer
16C	83	4-methyl-2-pentanone
16D	84	hexanal isomer
16E	86	2,3-dimethylhexane
17	87	toluene
17A	89	2,4-dimethylhexane
17B	90	3-methylheptane
17C	91	C_8H_{16} isomer
17D	92	dimethylcyclohexane isomer
18	93	n-hexanal
18A	94	C_8H_{16} isomer
18B	95	C_8H_{16} isomer
19	95	n-octane
19A	96	C_8H_{16} isomer
20	100	hexamethylcyclotrisiloxane (BKG)
20A	102	C_9H_{18} isomer
20B	103	ethylcyclohexane
20C	103	C_9H_{18} + C_9H_{20} isomers
21	105	2-heptanone
22	106	ethylbenzene
22A	107	C_9H_{18} isomer
23	108	p-xylene
24	109	C_9H_{20} isomer
25	110	C_9H_{20} isomer
25A	111	C_9H_{18} isomer
26	111	styrene
26A	112	C_9H_{16} isomer
26B	112	o-xylene + C_9H_{18} isomer
27	113	n-heptaldehyde
27A	114	C_9H_{18} isomer
28	115	n-nonane
29	117	C_9H_{18} isomer
29A	118	isopropylbenzene
30	119	$C_{10}H_{22}$ isomer
30A	121	propylcyclohexane
31	122	terpinene isomer
32	123	benzaldehyde
32A	124	n-propylbenzene
33	125	p-ethyltoluene
34	127	m-ethyltoluene + $C_{10}H_{22}$ isomer
34A	127	$C_{10}H_{20}$ isomer
35	128	$C_{11}H_{24}$ isomer
36	129	o-ethyltoluene + $C_{10}H_{22}$ isomer
36A	130	$C_{10}H_{16}$ isomer
37	131	octanone (tent.) + $C_{10}H_{20}$ isomers
38	132	1,2,4-trimethylbenzene + $C_{10}H_{20}$ isomers
38A	133	$C_{10}H_{20}$ isomer
39	134	n-decane
39A	135	$C_{10}H_{20}$ isomer
40	136	triisobutylene
40A	137	1,2,3-trimethylbenzene

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Table B-3. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
40B	137	C_4-alkyl benzene isomer
41	138	$C_{11}H_{24}$ isomer
42	139	$C_{11}H_{24}$ isomer
42A	140	butylcyclohexane + $C_{11}H_{22}$ isomer
43	141	$C_{11}H_{24}$ isomer
44	142	$C_{12}H_{26}$ isomer
44A	142	$C_{11}H_{24}$ isomer
44B	143	C_4-alkyl benzene + $C_{11}H_{22}$ isomers
45	143	acetophenone
45A	144	$C_{11}H_{22}$ isomer
46	145	$C_{11}H_{24}$ isomer
47	147	C_4-alkyl benzene + $C_{12}H_{26}$ isomers
48	148	C_4-alkyl benzene isomer
49	149	$C_{12}H_{26}$ isomer
50	150	$C_{11}H_{22}$ isomer
50A	151	$C_{11}H_{22}$ isomer
50B	151	$C_{12}H_{24}$ isomer
51	152	n-undecane
51A	153	C_4-alkyl benzene isomer
51B	154	$C_{12}H_{24}$ isomer
52	155	$C_{12}H_{26}$ isomer
52A	155	$C_{11}H_{20}$ isomer
53	157	$C_{12}H_{26}$ isomer
53A	158	C_5-alkyl benzene
54	159	pentylcyclohexane
54A	160	$C_{12}H_{24}$ isomer
55	161	C_4-alkyl benzene
56	161	dimethylphanol
56A	162	$C_{12}H_{26}$ isomer
57	163	ethylphenol + C_4-alkyl benzene isomer
58	164	$C_{12}H_{26}$ isomer
59	165	$C_{12}H_{24}$ isomer
60	167	$C_{12}H_{24}$ isomer
61	169	n-dodecane
62	171	$C_{13}H_{28}$ isomer
62A	172	$C_{13}H_{26}$ isomer
62B	174	$C_{13}H_{26}$ isomer
62C	176	$C_{12}H_{24}$ isomer

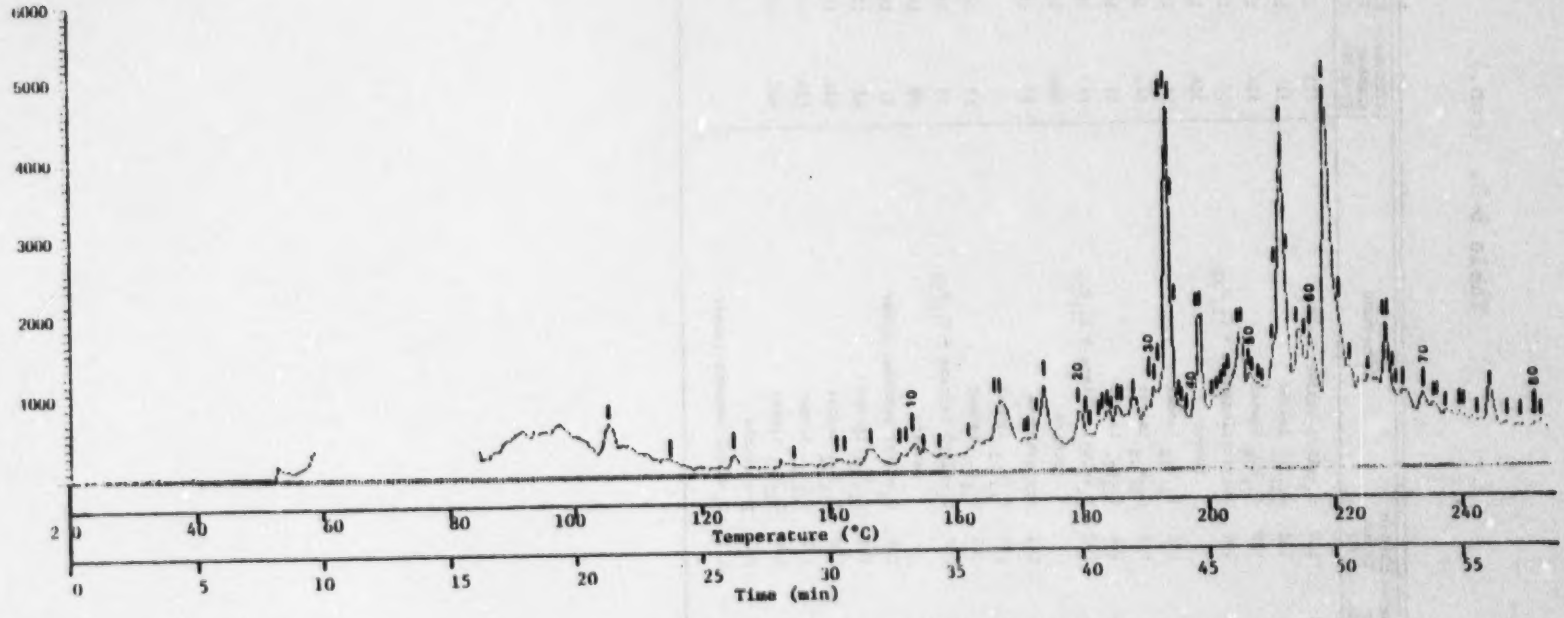

Figure B-4. Total ion current plot during gas liquid chromatography/mass spectrometry of air sample from the interior of a Chevette (8/25/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 6.42 ℓ.
Note: a = Interference due to water.

Table B-4. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-4.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	104	3,3-dimethylcyclobutanecarbonitrile
2	113	methyl hexyne
3	123	toluene
4	130	hexamethylcyclotrisiloxane (tent.)
5	137	C_8H_{16} isomer
6	140	alkylated cyclohexane
7	144	C_2-benzene
8	149	cyclooctatetraene (or styrene)
9	150	C_2-benzene
10	151	C_9H_{20} isomer
11	153	maleic anhydride (tent.)
12	155	phenol
13	161	C_9H_{18} isomer
14	164	C_3-benzene
15	165	benzaldehyde
16	168	aniline
17	168	2-amino-2-methyl-1-propanol
18	170	C_3-benzene
19	171	$C_{10}H_{22}$ isomer
20	177	C_4-benzene
21	178	C_8H_{16} isomer
22	179	C_8H_{12} isomer
23	181	$C_{10}H_{20}$ isomer
24	182	$C_{10}H_{22}$ isomer
25	182	C_4-benzene
26	183	$C_{10}H_{22}$ isomer
27	183	cresol
28	183	$C_{11}H_{22}$ isomer
29	185	C_4-benzene
30	187	C_4-benzene
31	187	$C_{10}H_{20}$ isomer
32	188	$C_{11}H_{22}$ isomer
33	190	$C_{11}H_{24}$ isomer
34	190	$C_{11}H_{22}$ isomer
35	190	$C_{11}H_{20}$ isomer
36	191	$C_{11}H_{29}$ isomer
37	192	C_5-benzene
38	194	$C_{11}H_{22}$ isomer
39	194	$C_{11}H_{24}$ isomer
40	194	C_4-benzene
41	196	C_4-benzene
42	196	$C_{11}H_{22}$ isomer
43	198	C_5-benzene
44	199	dimethylstyrene
45	199	C_5-benzene
46	201	$C_{12}H_{24}$ isomer
47	201	$C_{12}H_{26}$ isomer
48	202	dimethylstyrene
49	202	C_5-benzene
50	204	$C_{12}H_{26}$ isomer
51	204	C_8-benzene
52	206	$C_{12}H_{24}$ isomer
53	206	$C_{11}H_{22}$ isomer
54	207	C_6-benzene
55	208	$C_{12}H_{26}$ isomer
56	208	naphthalene
57	209	C_5-benzene
58	211	$C_{13}H_{28}$ isomer
59	212	C_6-benzene
60	213	C_6-benzene
61	216	benzothiazole [C_7H_5NS]
62	217	$C_{13}H_{28}$ isomer
63	219	C_6-benzene
64	221	C_5-indoline
65	225	$C_{13}H_{28}$ isomer
66	225	C_5-benzene
67	226	C_6-benzene
68	227	C_7-benzene
69	228	β-methylnaphthalene
70	230	α-methylnaphthalene
71	232	di-t-butylphenanthylene (tent.)
72	233	C_7-benzene
73	234	$C_{13}H_{26}$ isomer
74	235	C_7-benzene
75	236	diphenoxybenzene
76	240	biphenyl
77	a	octamethyltrisiloxane
78	a	$C_{11}H_{24}$ isomer
79	a	dimethylnaphthalene
80	a	?-phthalate
81	a	dimethylnaphthalene

a = Isothermal

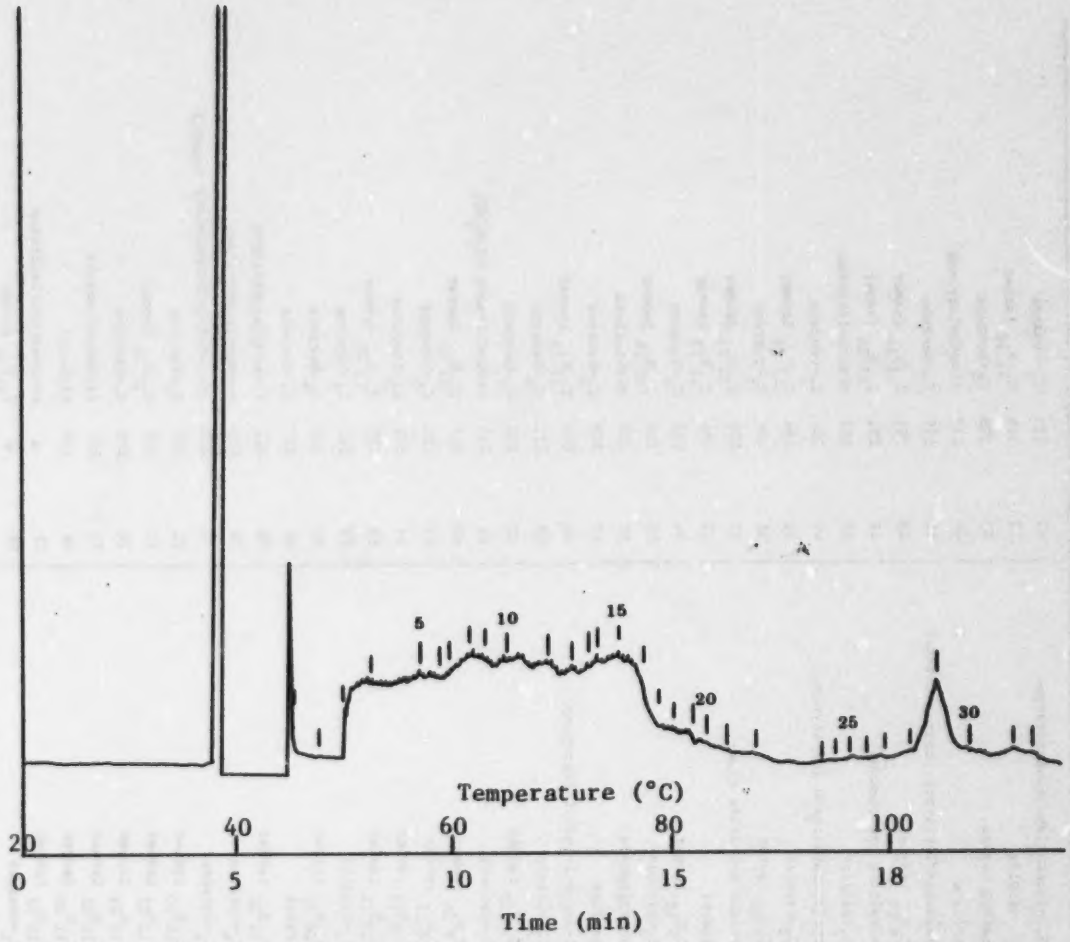

Figure B-5. Total ion current plot during gas liquid chromatography/mass spectrometry of air sample from the interior of a Pinto (8/28/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 32 ℓ.

(con.)

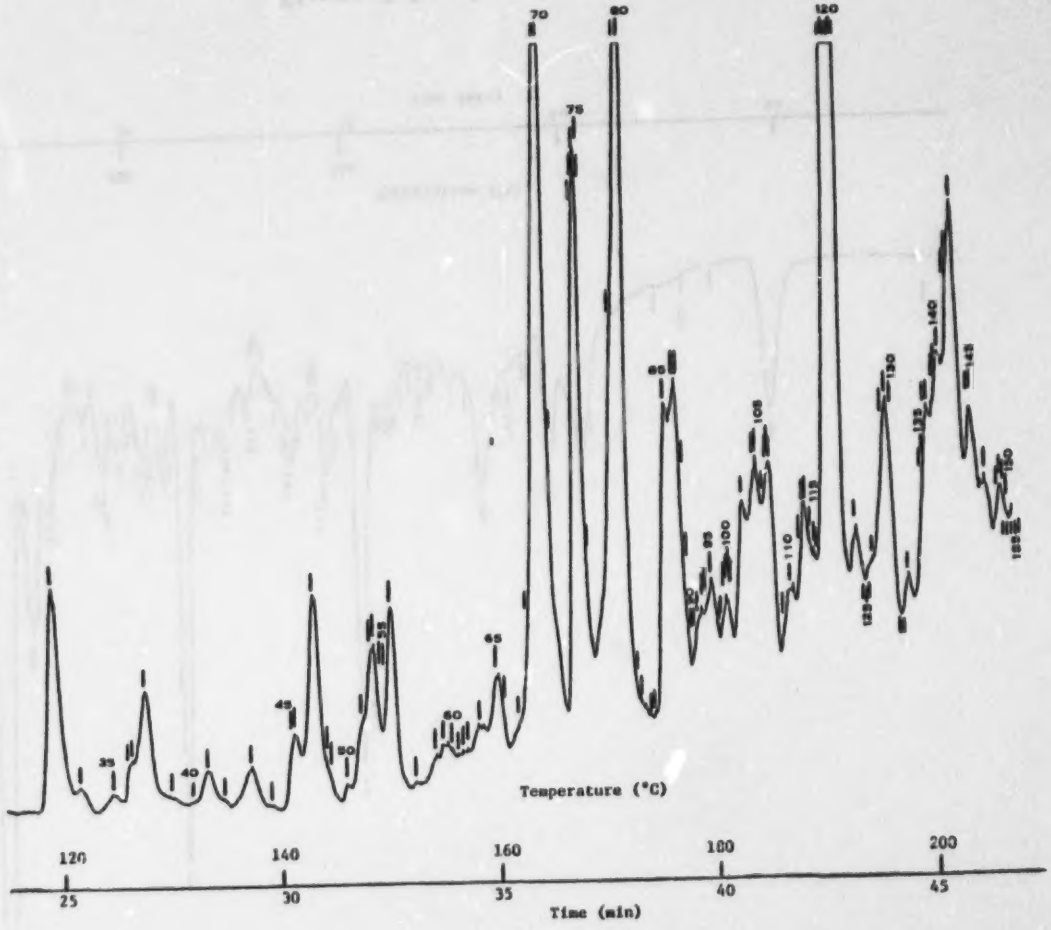

Figure B-5. (con.)

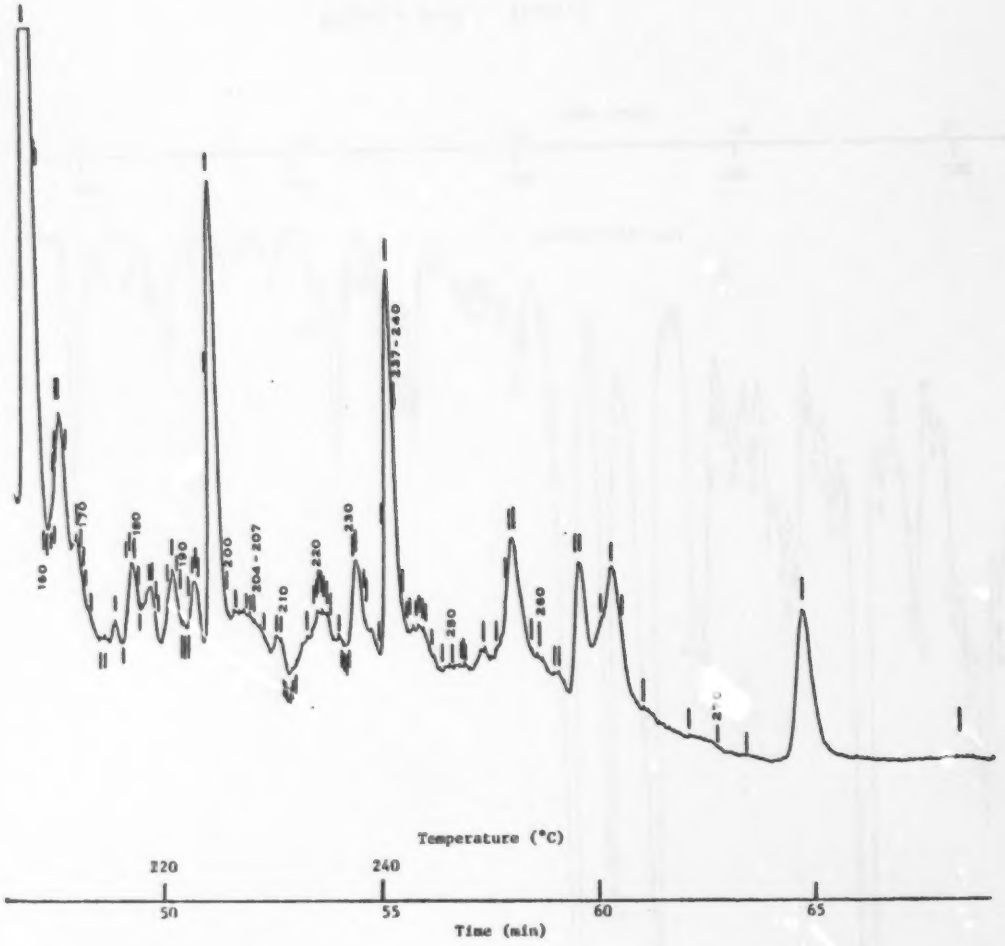

Figure B-5. (con.)

Table B-5. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-5.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	45	CO_2
2	47	C_4H_8 isomer
3	50	C_4H_8 isomer
4	52	C_4H_{10} isomer
5	57	C_5H_{10} isomer
6	58	C_5H_{10} isomer
7	59	C_5H_{12} isomer
8	61	C_5H_{10} isomer
9	63	C_5H_{12} isomer
10	64	vinyl methyl ether (tent.)
11	68	C_6H_{14} isomer
12	71	C_4H_{10} isomer
13	72	C_5H_{12} isomer
14	73	C_5H_{10} isomer
15	75	acetone
16	77	C_6H_{12} isomer
17	78	C_5H_{10} isomer
18	80	C_6H_{14} isomer
19	82	C_6H_{14} isomer
20	83	ethyl vinyl ether
21	84	methylene chloride
22	88	C_5H_{12} isomer
23	94	C_7H_{14} isomer
24	95	benzene
25	96	C_6H_{12} isomer
26	98	C_7H_{14} isomer
27	99	C_7H_{16} isomer
28	102	C_7H_{16} isomer
29	104	C_7H_{16} isomer
30	107	C_7H_{14} isomer
31	111	cyclohexylamine (tent.)
32	113	C_7H_{14} isomer
33	119	toluene
34	122	C_8H_{18} isomer
35	125	C_8H_{16} isomer
36	126	C_8H_{16} isomer
37	126	C_8H_{18} isomer
38	128	C_8H_{18} isomer
39	130	C_8H_{16} isomer
40	132	C_9H_{20} isomer
41	133	C_8H_{16} isomer
42	135	C_9H_{18} isomer
43	138	C_9H_{18} isomer
44	139	ethylbenzene
45	141	C_9H_{18} isomer
46	141	C_9H_{20} isomer
47	143	xylene (p and/or m)
48	144	C_9H_{18} isomer
49	144	C_9H_{20} isomer
50	146	C_9H_{18} isomer
51	147	styrene or cyclooctatetraene
52	148	o-xylene
53	148	C_9H_{18} isomer
54	149	C_9H_{18} isomer
55	149	C_9H_{20} isomer
56	150	C_9H_{20} isomer
57	152	N-ethylpyridine (tent.)
58	154	ethyl butyraldehyde (tent.)
59	155	C_9H_{18} isomer
60	155	C_3-alkyl benzene isomer
61	156	C_9H_{18} isomer
62	157	C_9H_{16} isomer
63	157	C_9H_{18} isomer
64	158	C_9H_{18} isomer
65	160	α-pinene
66	161	$C_{10}H_{20}$ isomer
67	162	C_3-alkyl benzene isomer
68	163	benzaldehyde
69	163	C_3-alkyl benzene isomer
70	163	phenol
71	164	C_3-alkyl benzene isomer
72	167	$C_{10}H_{20}$ isomer
73	167	C_3-alkyl benzene isomer
74	167	methylstyrene
75	167	C_9H_{20} isomer
76	167	$C_{10}H_{18}$ isomer
77	168	$C_{10}H_{20}$ isomer
78	170	C_3-alkyl benzene isomer
79	171	$C_{10}H_{22}$ isomer
80	171	$C_{10}H_{22}$ isomer
81	173	$C_{11}H_{22}$ isomer
82	174	C_4-alkyl benzene
83	175	$C_{11}H_{22}$ isomer
84	175	$C_{11}H_{24}$ isomer
85	176	C_4-alkyl benzene isomer
86	176	$C_{11}H_{24}$ isomer
87	176	C_4-alkyl benzene isomer
88	177	$C_{11}H_{22}$ isomer
89	177	$C_{12}H_{26}$ isomer
90	178	m-cresyl ethyl ether
91	178	$C_{11}H_{22}$ isomer
92	178	dichlorobenzene

Table B-5. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
93	178	$C_{12}H_{26}$ isomer
94	179	$C_{14}H_{26}$ isomer
95	180	C_4-alkyl benzene isomer
96	180	C_4-alkyl benzene isomer
97	180	$C_{12}H_{26}$ isomer
98	181	C_4-alkyl benzene isomer
99	181	$C_{11}H_{22}$ isomer
100	181	$C_{11}H_{24}$ isomer
101	181	$C_{12}H_{26}$ isomer
102	182	cresol
103	183	C_4-alkyl benzene isomer
104	183	$C_{11}H_{22}$ isomer
105	184	$C_{12}H_{26}$ isomer
106	185	C_4-alkyl benzene isomer
107	185	$C_{12}H_{24}$ isomer
108	185	decahydronaphthalene (tent.)
109	186	C_4-alkyl benzene isomer
110	187	$C_{12}H_{24}$ isomer
111	188	C_2-alkyl styrene isomer
112	188	$C_{11}H_{22}$ isomer
113	188	$C_{11}H_{20}$ isomer
114	188	$C_{12}H_{24}$ isomer
115	189	C_5-alkyl benzene isomer
116	189	$C_{12}H_{26}$ isomer
117	191	$C_{11}H_{24}$ isomer
118	191	$C_{11}H_{22}$ isomer
119	191	C_5-alkyl benzene isomer
120	191	$C_{12}H_{24}$ isomer
121	191	$C_{12}H_{26}$ isomer
122	191	$C_{12}H_{24}$ isomer
123	193	C_5-alkyl benzene isomer
124	193	$C_{11}H_{22}$ isomer
125	193	$C_{12}H_{24}$ isomer
126	193	$C_{12}H_{26}$ isomer
127	194	C_4-alkyl benzene isomer
128	196	$C_{12}H_{24}$ isomer
129	196	$C_{12}H_{26}$ isomer
130	196	C_5-alkyl benzene isomer
131	197	C_5-alkyl benzene isomer
132	197	$C_{12}H_{24}$ isomer
133	198	biphenylene
134	199	C_5-alkyl benzene isomer
135	199	$C_{12}H_{24}$ isomer
136	201	C_2-alkyl styrene isomer
137	201	$C_{11}H_{22}$ isomer
138	201	C_5-alkyl benzene isomer
139	201	$C_{12}H_{26}$ isomer
140	201	$C_{12}H_{24}$ isomer
141	202	C_2-alkyl styrene isomer
142	202	C_5-alkyl benzene isomer
143	202	$C_{12}H_{24}$ isomer
144	204	C_5-alkyl benzene isomer
145	204	C_2-alkyl styrene isomer
146	205	$C_{13}H_{26}$ isomer
147	206	$C_{13}H_{28}$ isomer
148	206	$C_{13}H_{26}$ isomer
149	206	$C_{13}H_{24}$ isomer
150	206	$C_{12}H_{24}$ isomer
151	208	C_5-alkyl benzene isomer
152	208	methyltetrahydronaphthalene
153	208	$C_{13}H_{26}$ isomer
154	208	$C_{12}H_{22}$ isomer
155	208	$C_{12}H_{24}$ isomer
156	208	$C_{12}H_{26}$ isomer
157	209	$C_{12}H_{26}$ isomer
158	210	naphthalene
159	210	C_5-alkyl benzene isomer
160	211	methyltetrahydronaphthalene
161	211	C_6-alkyl benzene isomer
162	211	$C_{12}H_{24}$ isomer
163	211	$C_{12}H_{28}$ isomer
164	211	$C_{13}H_{26}$ isomer
165	211	$C_{11}H_{14}$ (dimethyldihydroindene or methyltetrahydronaphthalene
166	212	$C_{13}H_{26}$ isomer
167	212	$C_{13}H_{28}$ isomer
168	212	C_6-alkyl benzene isomer
169	213	$C_{13}H_{28}$ isomer
170	214	C_6-alkyl benzene isomer
171	214	$C_{13}H_{26}$ isomer
172	214	$C_{13}H_{28}$ isomer
173	214	$C_{13}H_{26}$ isomer
174	215	$C_{13}H_{24}$ isomer
175	215	$C_{11}H_{14}$ isomer
176	216	$C_{13}H_{26}$ isomer
177	216	trimethylphenoxysilane (BKG)
178	214	benzothiazole
179	217	$C_{13}H_{26}$ isomer
180	217	C_6-alkyl benzene isomer
181	218	$C_{13}H_{28}$ isomer
182	218	C_7-alkyl benzene isomer
183	219	$C_{11}H_{14}$ isomer

Table B-5. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
134	219	$C_{14}H_{23}$ isomer
135	220	phenylpyridine (tent.)
136	220	$C_{13}H_{26}$ isomer
137	220	$C_{14}H_{30}$ isomer
138	222	C_7-alkyl benzene isomer
139	222	$C_{14}H_{28}$ isomer
140	222	trimethylindoline (tent.)
141	223	$C_{14}H_{30}$ isomer
142	223	$C_{13}H_{24}$ isomer
143	223	$C_{13}H_{26}$ isomer
144	223	$C_{14}H_{28}$ isomer
145	223	$C_{13}H_{28}$ isomer
146	223	$C_{14}H_{26}$ isomer
147	223	$C_{14}H_{28}$ isomer
148	224	$C_{13}H_{28}$ isomer
149	225	$C_{14}H_{28}$ isomer
150	227	unsatu.ated C_6-alkyl benzene isomer
151	228	β-methylnaphthalene
152	229	$C_{14}H_{28}$ isomer
153	229	$C_{14}H_{30}$ isomer
154	229	$C_{13}H_{30}$ isomer
155	229	unsaturated C_7-alkyl benzene isomer
156	229	$C_{14}H_{28}$ isomer
157	229	$C_{13}H_{24}$ isomer
158	230	C_7-alkyl benzene isomer
159	231	α-methylnaphthalene
160	231	$C_{12}H_{16}$ isomer
161	232	$C_{15}H_{30}$ isomer
162	232	$C_{14}H_{28}$ isomer
163	232	$C_{14}H_{26}$ isomer
164	232	C_7-alkyl benzene isomer
165	232	unsaturated C_7-alkyl benzene isomer
166	234	$C_{16}H_{32}$ isomer
167	234	C_8-alkyl benzene isomer
168	235	$C_{15}H_{30}$ isomer
169	235	$C_{15}H_{28}$ isomer
170	235	$C_{14}H_{24}$ isomer
171	235	C_7-alkyl benzene isomer
172	235	unsaturated C_7-alkyl benzene isomer
173	235	$C_{14}H_{28}$ isomer
174	235	$C_{16}H_{32}$ isomer
175	236	$C_{12}H_{16}$ isomer
176	238	C_9-alkyl benzene isomer
177	238	$C_{16}H_{32}$ isomer
178	238	$C_{12}H_{16}$ isomer
179	238	$C_{17}H_{36}$ isomer
180	238	$C_{15}H_{32}$ isomer
181	239	$C_{14}H_{28}$ isomer
182	239	unsaturated C_7-alkyl benzene isomer
183	239	$C_{14}H_{26}$ isomer
184	240	$C_{16}H_{34}$ isomer
185	240	biphenyl
186	240	$C_{14}H_{30}$ isomer
187	240	$C_{14}H_{28}$ isomer
188	240	$C_{14}H_{26}$ isomer
189	240	$C_{14}H_{24}$ isomer
190	240	$C_{14}H_{22}$ isomer
191	240	$C_{15}H_{30}$ isomer
192	240	$C_{12}H_{16}$ isomer
193	240	$C_{12}H_{26}$ isomer
194	240	$C_{15}H_{30}$ isomer
195	240	$C_{15}H_{26}$ isomer
196	240	$C_{15}H_{26}$ isomer
197	240	$C_{15}H_{24}$ isomer
198	240	$C_{15}H_{30}$ isomer
199	240	unsaturated C_8-alkyl benzene isomer
200	240	dimethylnaphthalene
201	240	$C_{16}H_{32}$ isomer
202	240	dimethyldihydronaphthalene
203	240	toluene diisocyanate (tent.)
204	240	dimethylnaphthalene
205	240	$C_{16}H_{32}$ isomer
206	240	$C_{15}H_{30}$ isomer
207	240	$C_{16}H_{34}$ isomer
208	240	unsaturated C_7-alkyl benzene isomer
209	240	phenylindole (tent.)
210	240	$C_{16}H_{28}$ isomer
211	240	$C_{15}H_{30}$ isomer
212	240	$C_{15}H_{32}$ isomer
213	240	$C_{15}H_{32}$ isomer
214	240	$C_{16}H_{32}$ isomer
215	240	octamethylcyclotetrasiloxane (BKG)
216	240	cedranone ($C_{15}H_{24}O$) (tent.)
217	240	$C_{16}H_{32}$ isomer
218	240	$C_{15}H_{28}$ isomer

TABLE B-5. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound	Chromatographic Peak No.	Elution Temp. (°C)	Compound
269	240	$C_{16}H_{32}$ isomer	272	240	long chain propyl ketone
270	240	diphenyl ether (tent.)	273	240	benzyl phenol (tent.)
271	240	phenyl phenol (tent.)			

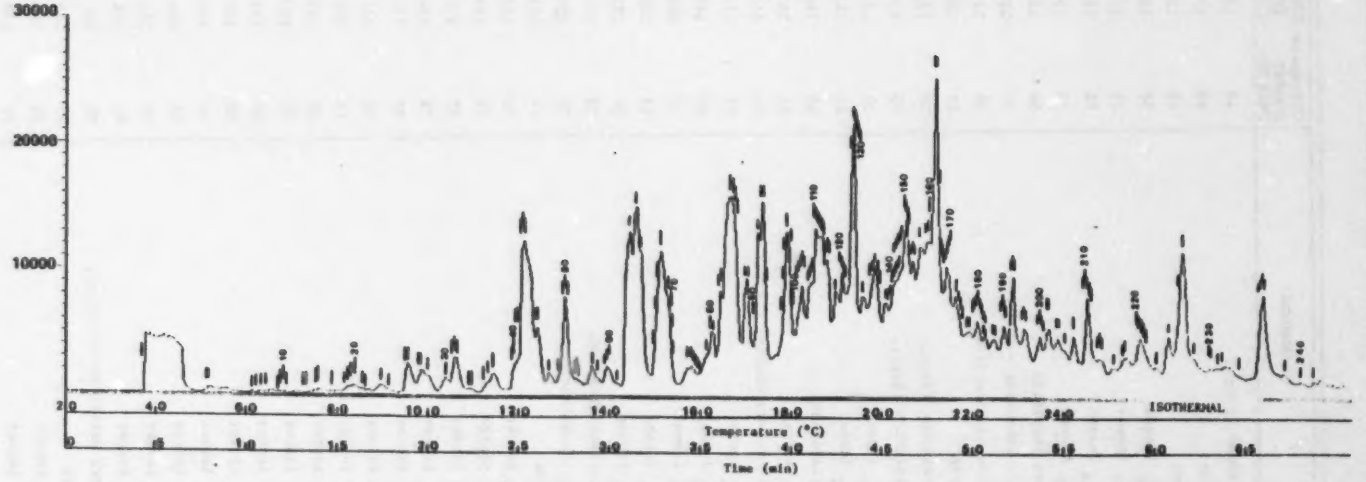

Figure B-6. Total ion current plot during gas liquid chromatography/mass spectrometry of air sample from the interior of a Gremlin (8/26/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 35.6 ℓ.

Table B-6. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-6.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	37	propylene (tent.)
2	51	butene
3	51	butane
4	58	C_5H_{10} isomer
5	58	C_5H_{12} isomer
6	60	C_5H_{10} isomer
7	62	C_5H_{10} isomer
8	66	carbon disulfide
9	66	maleic anhydride (tent.)
10	66	propane nitrile (tent.)
11	67	pentyne
12	69	chlorobutane (tent.)
13	70	diethylamine (tent.)
14	72	C_6H_{14} isomer
15	74	C_6H_{12} isomer
16	78	Methylpentane
17	80	C_6H_{12} isomer
18	81	methyl sec-butylamine (tent.)
19	82	C_6H_{14} isomer
20	82	C_6H_{12} isomer
21	85	C_6H_{14} isomer
22	85	C_6H_{10} isomer
23	87	C_6H_{12} isomer
24	90	1,1,1-trichloroethane
25	94	C_6H_{10} [hexadiene]
26	95	benzene
27	97	C_7H_{16} isomer
28	97	C_7H_{14} isomer
29	99	C_7H_{16} isomer
30	103	C_7H_{14} isomer
31	104	C_7H_{16} isomer
32	105	C_7H_{12} isomer
33	106	C_7H_{14} isomer
34	108	C_7H_{12} isomer
35	109	C_8H_{16} isomer
36	111	C_7H_{14} isomer
37	113	C_8H_{16} isomer
38	113	C_8H_{18} isomer
39	116	C_8H_{16} isomer
40	118	C_7H_{16} isomer
41	118	C_7H_{20} isomer
42	118	furfuryl methyl ether (tent.)
43	120	toluene
44	120	C_8H_{15} isomer
45	121	C_8H_{16} isomer
46	122	C_8H_{16} isomer
47	122	C_8H_{18} isomer
48	125	C_5H_{16} isomer
49	127	dimethyl-1,4-dioxolane (tent.)
50	128	C_8H_{14} isomer
51	128	C_8H_{16} isomer
52	128	C_8H_{18} isomer
53	130	C_8H_{16} isomer
54	131	C_8H_{14} isomer
55	132	hexamethylcyclotrisiloxane (BKG)
56	134	C_9H_{20} isomer
57	135	C_9H_{18} isomer
58	137	C_8H_{16} isomer
59	138	C_8H_{18} isomer
60	138	C_9H_{18} isomer
61	142	C_2-benzene
62	144	C_2-benzene
63	145	chlorocyclohexanol (tent.)
64	145	C_9H_{18} isomer
65	149	styrene
66	149	C_2-benzene
67	149	C_9H_{18} isomer
68	150	C_9H_{20} isomer
69	152	pyridine
70	153	C_3-benzene
71	153	C_9H_{16} isomer
72	153	C_9H_{18} isomer
73	154	C_9H_{18} isomer
74	155	C_3-benzene
75	156	$C_{10}H_{22}$ isomer
76	156	hexenyl hexenoate
77	157	C_9H_{16} isomer
78	157	$C_{10}H_{22}$ isomer
79	158	n-propylcyclohexane
80	159	a-pinene
81	160	$C_{10}H_{20}$ isomer
82	161	n-propylbenzene
83	162	benzaldehyde
84	163	phenol
85	164	$C_{10}H_{20}$ isomer
86	164	$C_{10}H_{22}$ isomer
87	166	methylstyrene
88	167	ethyl toluene
89	168	$C_{10}H_{18}$ isomer
90	169	$C_{10}H_{16}$ isomer
91	170	C_3-benzene
92	170	$C_{10}H_{20}$ isomer

Table B-6. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
93	170	$C_{10}H_{22}$ isomer
94	172	$C_{11}H_{22}$ isomer
95	173	$C_{11}H_{20}$ isomer
96	174	C_4-benzene
97	174	$C_{11}H_{24}$ isomer
98	176	C_4-benzene
99	177	$C_{11}H_{22}$ isomer
100	178	cresol ethyl ether
101	179	$C_{11}H_{22}$ isomer
102	179	$C_{11}H_{24}$ isomer
103	180	methylstyrene
104	180	$C_{10}H_{20}$ isomer
105	180	$C_{11}H_{22}$ isomer
106	181	C_4-benzene
107	181	$C_{11}H_{22}$ isomer
108	181	C_4-benzene
109	181	$C_{11}H_{24}$ isomer
110	182	$C_{12}H_{26}$ isomer
111	182	cresol
112	182	$C_{11}H_{24}$ isomer
113	183	$C_{11}H_{22}$ isomer
114	183	C_4-benzene
115	183	$C_{12}H_{26}$ isomer
116	184	$C_{11}H_{22}$ isomer
117	185	C_4-benzene
118	185	chlorostyrene
119	185	$C_{11}H_{22}$ isomer
120	186	$C_{11}H_{20}$ isomer
121	186	$C_{12}H_{24}$ isomer
122	188	diethylstyrene
123	189	$C_{11}H_{22}$ isomer
124	189	$C_{11}H_{24}$ isomer
125	189	$C_{11}H_{22}$ isomer
126	190	C_5-benzene
127	192	C_5-benzene
128	192	$C_{11}H_{22}$ isomer
129	192	$C_{12}H_{24}$ isomer
130	193	$C_{12}H_{26}$ isomer
131	193	dimethylindane
132	194	$C_{12}H_{26}$ isomer
133	194	C_5-benzene
134	195	$C_{11}H_{20}$ isomer
135	196	$C_{12}H_{22}$ isomer
136	196	methyl anisole
137	197	C_5-benzene
138	197	$C_{11}H_{20}$ isomer
139	197	$C_{12}H_{24}$ isomer
140	199	dimethyl styrene
141	199	$C_{11}H_{22}$ isomer
142	200	dimethyl phenol
143	200	C_5-benzene
144	200	$C_{12}H_{26}$ isomer
145	200	$C_{12}H_{24}$ isomer
146	200	$C_{12}H_{22}$ isomer
147	200	$C_{12}H_{20}$ isomer
148	200	$C_{12}H_{18}$ isomer
149	201	C_5-benzene
150	202	hexachloroethane (tent.)
151	202	C_5-benzene
152	202	$C_{11}H_{24}$ isomer
153	203	chloroethylbenzene (tent.)
154	204	tetrahydronaphthalene
155	204	$C_{13}H_{26}$ isomer
156	204	$C_{13}H_{28}$ isomer
157	205	dimethylphenol
158	206	$C_{12}H_{18}$ isomer
159	207	C_5-benzene
160	208	methyltetrahydronaphthalene
161	208	naphthalene
162	208	$C_{12}H_{26}$ isomer
163	209	C_5-benzene
164	210	C_6-benzene
165	210	methyltetrahydronaphthalene
166	211	$C_{12}H_{24}$ isomer
167	211	$C_{12}H_{22}$ isomer
168	211	$C_{13}H_{26}$ isomer
169	211	$C_{13}H_{28}$ isomer
170	212	C_6-benzene
171	212	C_6-benzene
172	213	$C_{13}H_{26}$ isomer
173	214	N-n-butyldiperidine (tent.)
174	215	C_6-benzene
175	216	methoxybenzaldehyde
176	216	$C_{13}H_{26}$ isomer
177	217	dimethyltetrahydronaphthalene
178	217	C_6-benzene
179	218	$C_{13}H_{24}$ isomer
180	218	$C_{13}H_{26}$ isomer
181	218	$C_{13}H_{28}$ isomer
182	218	methyltetrahydronaphthalene
183	220	C_7-benzene
184	221	$C_{13}H_{24}$ isomer

Table B-6. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
195	221	$C_{13}H_{26}$ isomer
196	221	$C_{13}H_{26}$ isomer
197	222	C_5-benzene
198	220	dimethyldihydroindene
199	223	C_7-benzene
190	223	$C_{12}H_{26}$ isomer
191	224	$C_{15}H_{32}$ isomer
192	224	$C_{13}H_{28}$ isomer
193	226	$C_{14}H_{28}$ isomer
194	226	ethyltetrahydronaphthalene
195	227	methylnaphthalene
196	228	C_7-benzene
197	228	$C_{13}H_{24}$ isomer
198	229	$C_{14}H_{28}$ isomer
199	230	methylnaphthalene
200	231	trimethylisopropenylbenzene
201	232	$C_{14}H_{28}$ isomer
202	232	C_7-benzene
203	233	diisobutylthiophene (?)
204	233	$C_{16}H_{32}$ isomer
205	234	phenylcyclohexene
206	235	$C_{15}H_{30}$ isomer
207	236	trimethylisopropenylbenzene
208	238	$C_{15}H_{32}$ isomer
209	239	biphenyl
210	240	$C_{14}H_{30}$ isomer
211	a	$C_{14}H_{30}$ isomer
212	a	$C_{14}H_{28}$ isomer
213	a	$C_{14}H_{26}$ isomer
214	a	C_6H_{14}-benzene
215	a	$C_{13}H_{30}$ isomer
216	a	dimethylnaphthalene
217	a	dimethylnaphthalene
218	a	dimethylnaphthalene
219	a	$C_{15}H_{30}$ isomer
220	a	$C_{15}H_{24}$ isomer
221	a	$C_{15}H_{28}$ isomer
222	a	dimethylnaphthalene
223	a	methoxyanthracene (tent.)
224	a	$C_{16}H_{30}$ isomer
225	a	dimethylnaphthalene
226	a	$C_{15}H_{32}$ isomer
227	a	di-t-butylcresol
228	a	$C_{15}H_{28}$ isomer
229	a	$C_{16}H_{32}$ isomer
230	a	C_4-tetrahydronaphthalene
231	a	$C_{16}H_{32}$ isomer
232	a	$C_{15}H_{28}$ isomer
233	a	$C_{16}H_{30}$ isomer
234	a	$C_{16}H_{32}$ isomer
235	a	$C_{15}H_{22}$ isomer
236	a	$C_{16}H_{28}$ isomer
237	a	$C_{16}H_{30}$ isomer
238	a	$C_{16}H_{34}$ isomer
239	a	$C_{16}H_{30}$ isomer
240	a	$C_{16}H_{30}$ isomer
241	a	$C_{17}H_{32}$ isomer

a = Isothermal

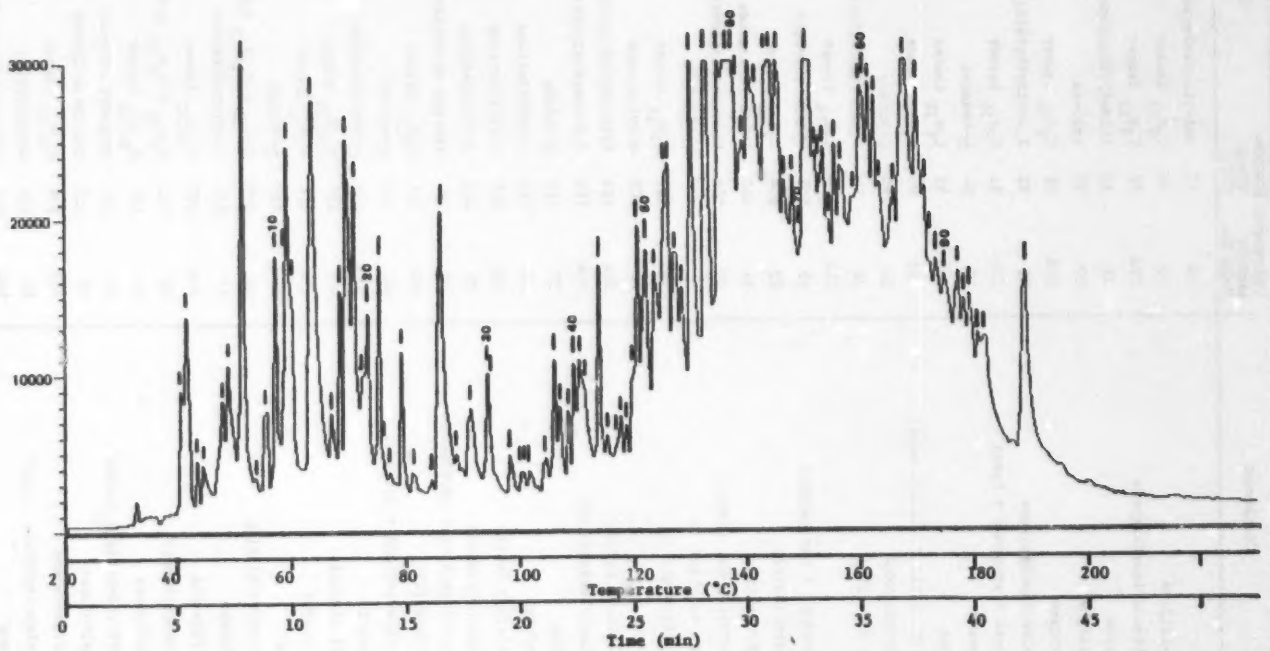

Figure B-7. Total ion current plot during gas liquid chromatography/mass spectrometry of air sample from the interior of a Rabbit (10/9/76) automobile. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 11.7 ℓ.

Table B-7. ORGANIC COMPOUNDS IDENTIFIED FROM FIGURE B-7.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	42	CO_2
1A	42	methylsilane
2	43	dichlorodifluoromethane
3	45	1-butene
4	46	acetaldehyde
5	50	isopentane
5A	50	trichlorofluormethane
5B	51	propenal + propanal + furan
6	51	n-pentane
6A	52	acetone
6B	52	dimethyl ether + diethyl ether
6C	53	dichloromethane
7	54	freon 113 (3KG)
7A	54	CS_2
7B	55	isopropanol + ter-butanol
8	56	isobutyraldehyde
9	58	2-methylpentane
9A	59	2-methylpropenal (tent.)
9B	59	diethyl sulphide
10	60	3-methylpentane
10A	60	n-butanal
10B	61	methyl vinyl ketone
11	61	hexafluorobenzene (eE)
12	62	n-hexane
13	63	chloroform
13A	64	methyl ethyl ketone
13B	65	2,4-dimethylpentane
14	66	methylcyclopentane + perfluoro-toluene (eE)
14A	66	1,2-dichloroethane + isobutyl alcohol
14B	68	n-butyl alcohol
14C	69	C_6H_{10} isomer
15	69	benzene
15A	70	carbon tetrachloride
16	71	cyclohexane
17	72	2-methylhexane
17A	73	2,3-dimethylhexane
18	74	3-methylhexane
19	75	dimethylcyclopentane isomer
19A	75	3-methylbutanal
20	76	trichloroethylene
20A	78	dimethylcyclopentane isomer
21	78	n-heptane
22	79	C_7H_{14} isomer
23	80	C_8H_{16} isomer
24	82	methylcyclohexane
25	84	C_8H_{18} isomer
25A	87	C_8H_{16} isomer
26	88	trimethylpentane isomer
27	89	toluene
27A	91	C_8H_{18} isomer
28	92	2,4-dimethylhexane
28A	93	C_8H_{16} isomer
29	94	n-hexanal
29A	95	C_8H_{16} isomer
29B	97	C_8H_{16} isomer
30	98	n-octane
31	98	tetrachloroethylene
31A	99	C_8H_{16} isomer
32	102	silane compound
33	104	C_9H_{20} isomer
34	105	ethylcyclohexane
35	106	trimethylcyclohexane + C_9H_{20} isomers
35A	107	C_9H_{18} isomer
36	108	ethylbenzene
36A	109	trimethylcyclohexane isomer
36B	110	2,3-dimethylheptane
37	110	p-xylene
38	111	2-methyloctane
38A	112	4-ethylheptane
39	113	3-ethylheptane
40	114	styrene or cyclooctatetraene
40A	114	C_9H_{18} isomer
41	115	o-xylene
41A	115	n-heptaldehyde
42	116	$C_{10}H_{20}$ isomer
42A	116	C_9H_{18} isomer
43	118	n-nonane
44	120	C_9H_{18} + $C_{10}H_{20}$ isomers
45	121	isopropylbenzene
45A	122	$C_{10}H_{22}$ isomer
46	122	C_9H_{16} + C_9H_{18} isomers
47	123	$C_{10}H_{22}$ isomer
48	124	propycyclohexane
49	125	terpinene isomer
49A	126	$C_{10}H_{22}$ isomer
50	126	benzaldehyde
50A	127	n-propylbenzene + $C_{10}H_{20}$ isomer
51	128	m-ethyltoluene

TABLE B-7. (con.)

Chromatographic Peak No.	Elution Temp. (°C)	Compound
51A	129	$C_{10}H_{22}$ isomer
52	130	1,3,5-trimethylbenzene
52A	130	$C_{10}H_{20}$ isomer
53	131	$C_{10}H_{22}$ isomer
54	132	o-ethyltoluene
54A	132	$C_{10}H_{22}$ isomer
54B	133	$C_{10}H_{20}$ isomer
55	133	$C_{10}H_{18}$ isomer
55A	134	$C_{10}H_{20}$ isomer
56	135	1,2,4-trimethylbenzene
56A	136	$C_{10}H_{20}$ isomer
57	138	n-decane
58	140	triisobutylene
58A	140	1,2,3-trimethylbenzene
59	141	C_4-alkyl benzene + $C_{10}H_{20}$ isomers
59A	142	$C_{11}H_{24}$ isomer
60	143	$C_{11}H_{22}$ isomer
61	143	$C_{11}H_{24}$ isomer
62	144	butylcyclohexane
62A	145	C_4-alkyl benzene + $C_{11}H_{24}$ isomers
63	145	p-propyltoluene
63A	146	$C_{11}H_{22}$ isomer
63B	146	n-butylbenzene
64	147	m-propyltoluene
64A	147	$C_{11}H_{22}$ isomer
64B	148	$C_{11}H_{24}$ isomer
65	148	o-propyltoluene
65A	149	$C_{10}H_{18}$ isomer
66	150	diethylbenzene isomer
66A	150	C_4-alkyl benzene isomer
67	151	$C_{11}H_{24}$ isomer
68	152	C_4-alkyl benzene isomer
69	154	$C_{11}H_{22}$ isomer
70	155	C_5-alkyl benzene + $C_{11}H_{22}$ isomers
71	156	n-undecane
71A	158	$C_{12}H_{26}$ isomer
72	158	$C_{12}H_{26}$ isomer
73	159	dimethylethylbenzene isomer
74	159	$C_{11}H_{20}$ isomer
75	160	$C_{12}H_{26}$ isomer
76	161	dimethylphenol isomer
76A	162	C_5-alkyl benzene isomer
77	163	$C_{12}H_{24}$ + $C_{11}H_{20}$ isomers
77A	163	pentylcyclohexane
77B	164	$C_{12}H_{24}$ isomer
77C	165	tetramethylbenzene isomer
78	165	dimethylphenol isomer
79	166	$C_{12}H_{26}$ isomer
80	167	$C_{12}H_{26}$ isomer
81	168	$C_{12}H_{24}$ isomer
81A	168	C_5-alkyl benzene isomer
82	169	$C_{12}H_{26}$ isomer
83	170	naphthalene
84	172	dodecene
85	174	n-dodecane
86	177	$C_{13}H_{28}$ isomer
87	178	$C_{13}H_{28}$ isomer
89	180	$C_{13}H_{26}$ isomer
90	182	hexylcyclohexane
90A	183	$C_{13}H_{26}$ isomer
91	184	$C_{13}H_{28}$ isomer
91A	184	$C_{13}H_{28}$ isomer
92	185	$C_{13}H_{28}$ isomer
93	186	2-methyldodecane
94	187	3-methyldodecane
95	189	$C_{14}H_{30}$ isomer
95A	193	$C_{13}H_{26}$ isomer
95B	194	$C_{14}H_{28}$ isomer
96	196	n-tridecane
96A	199	$C_{14}H_{30}$ isomer
96B	205	$C_{14}H_{28}$ isomer
96C	208	$C_{14}H_{28}$ isomer

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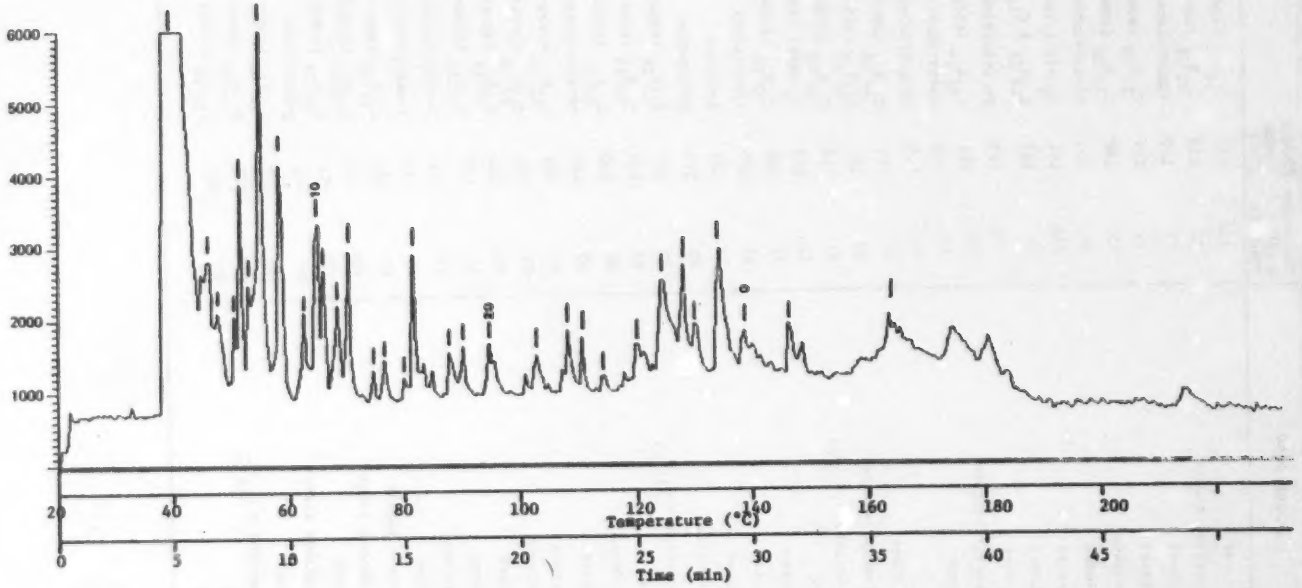

Figure B-8. Total ion current plot during gas liquid chromotography/mass spectrometry of a background air sample. A 100 m OV-101 SCOT capillary column was used. See text for conditions. Sample volume 35.6 ℓ.

Table B-8. ORGANIC COMPOUNDS IDENTIFIED IN AMBIENT AIR BACKGROUND ADJACENT TO THE GREMLIN.

Chromatographic Peak No.	Elution Temp. (°C)	Compound
1	39	methylsilane (BKG)
1A	42	CO_2
2	45	isopentane
2A	46	C_5H_{10} isomer
2B	47	acetaldehyde
2C	48	C_5H_{10} isomer
3	49	acetone + freon 113 (BKG)
4	52	C_6H_{12} isomer
5	53	2-methylpentane
5A	54	3-methylpentane
6	55	hexafluorobenzene (eE)
7	56	n-hexane
7A	57	chloroform
7B	58	C_6H_{12} isomer
8	59	perfluorotoluene (eE)
8A	60	methylcyclopentane
9	64	benzene
9A	65	carbon tetrachloride
9B	65	cyclohexane
10	66	2-methylhexane
10A	67	2,3-dimethylpentane
11	68	3-methylhexane
11A	69	dimethylcyclopentane isomer
12	70	C_7H_{16} isomer
12A	71	C_7H_{14} isomer
13	72	n-heptane
13A	73	C_7H_{14} isomer
13B	76	C_7H_{14} isomer
14	77	methycyclohexane
15	79	C_8H_{18} isomer
16	82	C_8H_{18} isomer
17	84	toluene
17A	85	C_8H_{18} isomer
17B	87	C_8H_{18} isomer
17C	88	C_8H_{16} isomer
18	90	C_8H_{18} isomer
19	92	n-octane
19A	93	tetrachloroethylene
20	97	silane compound (BKG)
20A	100	C_9H_{20} isomer
20B	103	ethylbenzene
21	105	p-xylene
21A	101	C_9H_{20} isomer
21B	108	C_9H_{20} isomer
21C	109	styrene
21D	110	o-xylene
22	111	C_9H_{18} isomer
23	113	n-nonane
24	117	silane compound (BKG)
24A	121	$C_{10}H_{22}$ isomer
25	124	benzaldehyde
25A	125	m-ethyltoluene
25B	126	C_3-alkylbenzene isomer
26	129	phenol
26A	131	p-ethyltoluene
27	132	$C_{10}H_{20}$ isomer
28	135	n-decane
28A	137	1,2,3-trimethylbenzene
29	138	$C_{11}H_{24}$ isomer
30	143	$C_{11}H_{24}$ isomer
30A	145	acetophenone
30B	146	$C_{11}H_{24}$ isomer
30C	148	C_4-alkyl benzene isomer
31	151	$C_{11}H_{24}$ isomer
32	154	n-undecane
32A	165	silane compound (BKG)
32B	170	$C_{12}H_{24}$ isomer
32C	187	β-methylnaphthalene
32D	190	α-methylnaphthalene

APPENDIX C

FREQUENCY-PRIORITIZED LIST OF ORGANICS FOUND IN AUTOMOBILE INTERIORS

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Table C-1. LIST OF ORGANICS

Compound	RABBIT	DATSUN	CHEVETTE	PINTO	GREMLIN	VEGA
n-propylbenzene	x	x	x	x	x	x
C_4-alkyl benzene isomers	x	x	x	x	x	x
C_5-alkyl benzene isomers	x	x	x	x	x	x
1-butene	x	x	x	x	x	x
terpinene isomers	x	x	x	x	x	x
$C_{11}H_{22}$ isomer	x	x	x	x	x	x
$C_{13}H_{26}$ isomer	x	x	x	x	x	x
C_9H_{16} isomer	x		x	x	x	x
C_9H_{18} isomer	x		x	x	x	x
$C_{11}H_{20}$ isomers		x	x	x	x	x
$C_{12}H_{26}$ isomers	x		x	x	x	x
$C_{12}H_{24}$ isomers	x		x	x	x	x
$C_{13}H_{28}$ isomers	x		x	x	x	x
dimethylphenol isomers	x	x	x		x	
dimethylstyrene		x	x		x	x
dimethylnaphthalenes			x	x	x	x
n-butane		x	x	x		x
n-pentane		x	x		x	x
C_6H_{10} isomers	x	x			x	x
C_8H_{16} isomers			x		x	x
$C_{10}H_{18}$ isomers	x		x	x	x	
butylcyclohexane	x		x		x	x
$C_{14}H_{30}$ isomers	x			x	x	x
$C_{14}H_{28}$ isomers	x			x	x	x
2-methyl-2-propanol	x	x	x			
cresol			x	x	x	
carbon disulfide	x			x	x	
benzothiazole	x		x			x
ethylbenzene		x	x	x		
C_6-alkylbenzene isomers				x	x	x
dimethyldihydroindene or methyltetrahydronaphthalene				x	x	x
C_7-alkylbenzene isomers				x	x	x
biphenyl			x	x	x	
methylstyrene isomers				x	x	x
naphthalene	x			x	x	
2-butene		x		x	x	

Table C-1 (con.)

Compound	RABBIT	DATSUN	CHEVETTE	PINTO	GREMLIN	VEGA
propylcyclohexane	x		x		x	
$C_{10}H_{22}$ isomers branched	x	x			x	
$C_{10}H_{16}$ isomers	x		x		x	
$C_{13}H_{24}$ isomers				x	x	x
$C_{15}H_{32}$ isomers				x	x	x
$C_{15}H_{30}$ isomers				x	x	x
$C_{16}H_{34}$ isomers				x	x	x
$C_{16}H_{32}$ isomers				x	x	x
1,2,4-trimethylbenzene	x	x	x			
propenal	x		x			
propanal	x		x			
2-methylpropenal (tent.)	x		x			
n-butanal	x		x			
n-hexanal	x		x			
long chain propyl ketone				x		x
di-t-butyl cresol					x	x
furan	x		x			
dimethyl ether	x		x			
vinyl methyl ether (tent.)				x		x
m-cresyl ethyl ether						
diphenyl ether (tent.)						
benzyl phenyl ether (tent.)						
o-propyltoluene	x	x				
p-xylene		x	x			
dimethylethylbenzene isomers	x	x				
dimethylindane					x	x
methyltetrahydronaphthalenes				x	x	
maleic anhydride (tent.)			x		x	
C_8H_{14} isomers		x			x	
$C_{10}H_{20}$ isomers	x		x			
pentylcyclohexane	x		x			
n-dodecane	x		x			
$C_{12}H_{22}$ isomers					x	x
$C_{14}H_{26}$ isomers				x	x	
$C_{15}H_{28}$ isomers				x	x	
$C_{15}H_{24}$ isomers				x	x	
$C_{17}H_{36}$ isomers				x	x	
1-butanol	x		x			
isopropylbenzene	x		x			

Table C-1 (con.)

Compound	RABBIT	DATSUN	CHEVETTE	PINTO	GREMLIN	VEGA
1,2-dibromoethane (tent.)		x				
chlorobutane (tent.)					x	
chlorocyclohexanol					x	
chlorostyrene (tent.)					x	
hexachloroethane (tent.)					x	
chloroethylbenzene (tent.)					x	
trichlorobenzene isomer						x
2-methylpropanal	x					
3-methylbutanal	x					
hexanal isomer			x			
3-methylbutanal			x			
n-heptanal	x					
2-butenal			x			
ethylbutanal (tent.)				x		
methoxybenzaldehyde					x	
methyl vinyl ketone	x					
methyl ethyl ketone	x					
4-methyl-2-pentanone			x			
2-heptanone			x			
octanone isomer (tent.)			x			
cedranone ($C_{15}H_{24}O$)				x		
2-propanol	x					
2-methyl-1-propanol	x					
2-methyl-1-butanol (tent.)			x			
undecenol (tent.)						x
ethylphenol isomer			x			
ethyl acetate			x			
hexenyl hexenate (tent.)					x	
diethyl ether	x					
ethyl vinyl ether				x		
furfuryl methyl ether (tent.)					x	
dimethyl-1,4-dioxane (tent.)					x	
methyl anisole					x	
butyl methyl ether						x
dihydropyran						x
anisole						x
diphenoxybenzene			x			
methoxyanthracene (tent.)					x	
phthalate			x			

TABLE C-1. (con.)

Compound	RABBIT	DATSUN	CHEVETTE	PINTO	CREMLIN	VEGA
N-methyl-2-butylamine (tent.)					x	
diethylamine (tent.)					x	
N-n-butylpiperidine (tent.)					x	
butylaminodiphenylamine (tent.)						x
2-amino-2-methyl-1-propanol			x			
cyclohexylamine (tent.)				x		
aniline			x			
trimethylindoline (tent.)				x		
phenylindole (tent.)				x		
pyridine (tent.)					x	
N-ethylpyridine (tent.)				x		
phenylpyridine (tent.)				x		
dimethylquinoline						x
propene nitrile (tent.)		x				
propane nitrile (tent.)				x		
3,3-dimethylcyclobutane carbonnitrile (tent.)			x			
toluene diisocyanate (tent.)				x		
diethyl sulfide		x				
diisobutylthiophene (tent.)					x	
C_8-alkyl thiOphene (tent.)						x
trimethylisopropylbenzene					x	
phenylcyclohexane					x	
C_8-alkyl benzene						x
C_2-alkyl styrene isomers				x		
diethylstyrene isomers					x	
di-t-butylphenanthrene (tent.)			x			
dimethyldihydronaphthalenes				x		
tetrahydronaphthalene					x	
ethyltetrahydronaphthalene					x	
C_4-alkyl tetrahydronaphthalene					x	
dimethyltetrahydronaphthalene						x
diethylbenzene isomer	x					
1,3,5-trimethyl benzene		x				
p-propyltoluene		x				
tetramethylbenzene isomer	x					
p-ethyltoluene			x			

Table C-1 (con.)

Compound	RABBIT	DATSUN	CHEVETTE	PINTO	CREMLIN	VEGA
biphenylene					x	
unsaturated C_6-alkyl benzene isomers					x	
unsaturated C_7-alkyl benzene isomers					x	
C_9-alkyl benzene isomer					x	
unsaturated C_8-alkyl benzene isomers					x	
propene (tent.)					x	
C_4H_{10} isomer				x		
cyclopentene		x				
pentyne					x	
C_5H_{10} isomer				x		
methylpentene		x				
C_7H_{12} isomer					x	
methyl hexyne			x			
methyl cyclohexene isomers		x				
ethylcyclohexane	x					
trimethylpentane isomer		x				
trimethylcyclohexane	x					
2,3-dimethylheptane	x					
$C_{10}H_{12}$ isomer		x				
decahydronaphthalene (tent.)				x		
triisobutylene			x			
$C_{12}H_{16}$ isomers				x		
$C_{12}H_{18}$ isomer					x	
hexylcyclohexane	x					
2-methyldodecane	x					
3-methyldodecane	x					
n-tridecane	x					
$C_{14}H_{24}$ isomers				x		
$C_{14}H_{22}$ isomers				x		
$C_{15}H_{26}$ isomers				x		
$C_{15}H_{22}$ isomers					x	
$C_{16}H_{28}$ isomers					x	
$C_{16}H_{30}$ isomers					x	